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Family forest owners and landscape-scale interactions: A review

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ABSTRACT

Forested landscapes around the world are owned, governed, and managed by many small owners and collectives. The management decisions that these owners and collectives make aggregate into measurable impacts on forest cover, fragmentation, carbon storage, biodiversity, and on the ecosystem services these forests provide to owners and broader society. Conversely, large scale processes such as climate change, globalization of markets, changes to laws regarding land tenure and access, and labor migration and remittances dramatically affect individual forest owners and the activities they are able to do on their land. Using NVivo 11.0, I coded and analyzed 456 papers describing research in the intersection of private or communal owners, forests, and landscape-scale impacts or influences. This analysis identified several prominent themes. Forested landscapes are increasingly split into smaller managed segments among more owners, in some cases facilitating deforestation. Global-scale processes such as labor migration and globalized forest product systems influence management decisions of family forest owners in most countries, particularly the choice of growing exotic species plantations and converting forests to cash crops. Programs and policies aimed at family and communal forest owners can be better targeted to incentivize these owners to protect and enhance forest benefits for broader society, and to better support owners' adaptations to climate change, invasive species, biodiversity loss, and population demographics. Forest-based tourism and non-timber forest products are important but undervalued incentives for forest conservation. Given the large proportion of forests owned and managed by smallholders, landscape-scale planning and conservation goals cannot be met without engaging these forest owners.

1. Introduction

At the global scale, land use and land cover change (LULCC) is a growing concern (Foley et al., 2005; Hansen et al., 2013). Rates and patterns of land use transitions have important implications for biodiversity conservation, climate change, urbanization, and natural resource management at multiple scales (Houghton et al., 2012; Mayer et al., 2016; Millennium Ecosystem Assessment, 2005; Newbold et al., 2015). In particular, forest gains and losses due to LULCC directly influence carbon emissions and climate change trends (Hansen et al., 2013; Houghton et al., 2012; Pan et al., 2011). Deforestation driven by increased demands for food and fuel in tropical forests contrasts with reforestation occurring on abandoned agricultural land in temperate forests, while plantations of fast-growing exotics for cash crops and timber are established on both natural forests and abandoned croplands (Meyfroidt, Rudel, & Lambin, 2010; Rudel et al., 2005; Sreeja, Madhusoodhanan, & Eldho, 2015). In many cases involving forest loss and gain, land use change is driven by economic needs and policies which incentivize (directly or indirectly) certain land use changes over others (Lambin et al., 2001; Verburg, Schulp, Witte, & Veldkamp, 2006).

Some global land use change can be attributed to the individual decision-making of many smallholders, with landscape- and regional-scale impacts and consequences when considered in the aggregate (Bliss, 2003; Hull, Robertson, & Buhyoff, 2004; Lambin et al., 2001; Ma & Kittredge, 2011; Miller, Munoz-Mora, & Christiaensen, 2017; Odum, 1982; Oestreicher et al., 2014; Oli, Treue, & Larsen, 2015; Pokorny & de Jong, 2015; Toledo-Hernández, Denmead, Clough, Raffiudin, & Tscharntke, 2016; Wear, Turner, & Flamm, 1996). There is a substantial body of literature regarding individual forest smallholders and their land management behavior, choices and goals (Gregory, Conway, & Sullivan, 2003; Hodgdon & Tyrrell, 2003; de Jong, Galloway, Katila, & Pacheco, 2016; Pokorny & de Jong, 2015; Straka, 2011; Sreeja et al., 2015). Owner-level studies examine demographics, management behaviors, values, and economic and social motivators, along with their local impacts on biodiversity, water quality, land use change, and market prices for land and resources. Although the larger-scale impacts of these individual decisions have been acknowledged for decades, only more recently has there been an explicit focus on the landscape-scale impacts of these owners, and the large-scale influences and pressures these owners face (Straka, 2011; Turner, Wear, & Flamm, 1996).

Earlier work on individual-level owner behavior may require

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revision due to the rapidly changing demographics of forest owners, ownership turnover, parcelization and privatization of forested landscapes, and forest transition pressures from urbanization, population growth (in developing countries), and population decline (in developed countries; DiGiano, Ellis, & Keys, 2013; Germain, Brazill, & Stehman, 2006; Kline, Azuma, & Alig, 2004; Ko & He, 2011; Straka, 2011). "Parcelization" is the subdivision of one parcel into multiple parcels, and "privatization" is a change in land tenure which allows for an individual to own a parcel and sell it with title. Landscape and regional scale planning and policy efforts can fail if landowner behaviors and motivations are assumed to be homogenous or not properly taken into account (Field, Dayer, & Elphick, 2017; Shi, Zhao, Aregay, Zhao, & Jiang, 2016). However, it remains an open question as to whether our knowledge of owner-scale behaviors and motivations can scale up to inform national and global policies, and whether global-scale goals regarding forest conservation and carbon sequestration can be properly adapted to generate the desired outcomes at regional- and owner-scales (Asare, Kyei, & Mason, 2013; Mertz et al., 2012; Pacheco, 2012; Verburg et al., 2006). The ability to upscale or downscale projections of forest losses and gains requires knowledge of the interaction between drivers (economic, social, environmental) and decision-makers at each scale, and whether these drivers operate similarly across scales (Redo, Grau, Aide, & Clark, 2012). The interaction of scale and drivers is also critical to identifying policy leakage, when forest protection or reforestation policies in some areas simply transfer deforestation to other areas (Mayer, Kauppi, Angelstam, Zhang, & Tikka, 2005; Meyfroidt et al., 2010).

This comprehensive review of the literature through December 2017 synthesizes the state of knowledge regarding the landscape-scale impact of family forest owners on forested landscapes, and the influence of large-scale drivers and pressures on private or communal forest owners around the world. Studies and reviews of private forest owners that are inclusive across industrial and developing countries are rare (e.g., Radel, Schmook, & McCandless, 2010; Sandewall, Wu, Khoa, He, & Ohlsson, 2015), however this broader inclusivity allows us to identify common land use change drivers and how owners affect and respond to them. These dynamics will be particularly important to understand how forest gains and losses driven by smallholders will impact biodiversity extinction, globalization of markets, ecosystem services provisioning, and global and regional climate change, and in turn how these global scale processes influence the land management decisions made by these diverse and numerous smallholders. This review concludes with a summary of planning and policy approaches, as well as critical needs for future research.

2. Methods

In this review, I use the term "family forest owner" or "smallholder" to be synonymous and broadly inclusive, including all forest and woodland owners who are not public entities nor are private entities with very large holdings (e.g., industrial owners). These kinds of small forest owners have been variously described as family forest owners, forest farm owners, nonindustrial private forest owners, communal owners, community forests, community-based forest management, ejidos, and smallholders, even though there are some inconsistencies in types of owners included and excluded in these terms (Butler et al., 2016; de Jong et al., 2016; Straka, 2011). "Ejidos" are communally-owned lands (originating from pre-Spanish colonization systems) that are recognized by the Mexican government, and can be divided into individual ownerships by the ejidos community. I used de Jong et al.'s (2016) definition of community forests, as groups of individuals or households that live in close proximity to each other and to the forest, with either *de jure* or *de facto* rights to use or access the forest, and exclude others from it.

Table 1
Terms used in the literature search. One term was used from each column, in all combinations.

Owner term	Ecosystem term	Scale term
Nonindustrial private	forest	landscape
family	woodland	region
smallholder		"large scale"
private		
household		
ejidos		
communal		

2.1. Step 1: search keywords and paper identification

Given that my primary objective was to synthesize papers explicitly conducted at the landscape scale, on forests, and focused on family forest owners, I developed three categories of terms, each of which had to be present in each search (Table 1). Using an "AND" connector between combinations of three terms, I conducted 42 unique searches, limiting my search to papers published on or before December 2017. I used primarily Web of Science (Thompson Reuters, New York) and Google Scholar (Google, Mountain View, CA). However, eleven papers were added after reading through references lists of included papers or were recommended by publisher databases; these papers used unusual words, spellings, or hyphenated phrases that obscured them from the keyword combinations I used. I continued until no new, unique and relevant papers were identified. One keyword combination, "community" AND "forest" AND "landscape", generated over 9000 papers in Web of Science, due to thousands of papers on ecological communities (not communal ownership); thus it was excluded from further analysis. In total, these searches generated over 1500 papers, however many papers were repeated across searches. Eliminating the repeated papers resulted in 483 unique papers.

2.2. Step 2: paper identification, screening, and eligibility

In a first pass, I eliminated 27 of the 483 papers that were either not in English (even if the abstract was in English the paper was excluded), not enhanced pdfs, or occasionally both. Excluding these non-English papers certainly reduced the number of papers about family forests in predominantly developing countries (i.e., those in Spanish about forests in Central and South America, and those in French about forests in Africa). Due to coding software requirements, I excluded papers that were not available as enhanced pdfs (i.e., were only available as scanned images of photocopies). The majority in this "non-enhanced" category was written more than two decades ago, and thus this review was skewed towards more recent publications. Older papers that were not available as enhanced pdfs were mainly focused on family forests in industrial countries that were published in regional or low-circulation journals, however I did not notice any additional biases with respect to subject.

I skimmed each abstract (and occasionally the entire paper if in doubt) of the remaining 456 papers, to ensure that the papers met all three search criteria of landscape-scale, family or smallholder ownership, and forests or woodlands. Papers needed to focus on forested private, family or communal properties AND the impacts of forest use or management actions at larger scales OR impacts of large scale processes (e.g., climate change, pest dispersal) on these small-scale forests. The lack of explicit mention of landscape or regional scale impacts or influences meant that some papers that would have otherwise qualified were excluded. Below I explain some of the specific decisions to include or exclude, as they shed light on the body of literature and on the sometimes fuzzy line for inclusion in this review.

2.2.1. Ownership: private, communal, and use-rights

To be included in the review, the target of the paper needed to be forest owners, not what non-owners thought about forest owners or private forests. If a paper's methodology included surveys or interviews, the target or focus of these questions needed to be owners or managers of family forests, not the management of publicly owned forests or large, privately owned forests or plantations. Another small category of exclusion was papers which referred to private forest owners tangentially, where the main focus was on non-owner actors such as the forestry profession (e.g., Knoot & Rickenbach, 2014; L'Roe & Allred, 2013). Papers were also excluded if the type of private forest owner (commercial or noncommercial) was not specified or readily apparent (e.g., Llewellyn et al., 1996). I also did not include papers discussing the collection of non-timber forest products (NTFP) from forests that were broadly speaking not owned by the collectors; this included many papers in Africa on NTFP collectors in state-owned forests, the use of public forests or forests within protected areas by local communities, or Europeans collecting NTFP from private family forests that were not their own (many European countries allow public access to all forests regardless of ownership for NTFP collection and recreation; e.g., Colby, 1988; Sisak, Reidl, & Dudik, 2016). Finally, I excluded papers that did not focus on nonindustrial private or family forests specifically, for example silviculture treatments across a variety of ownerships, or those focused on deforestation with no discussion of forest use by smallholders beyond converting it to non-forest uses.

I included studies using interviews of forest professionals or natural resource managers that were specifically about private forest owners (e.g., Lidskog & Löfmarck, 2016). This included papers that surveyed local households about community-managed forests (common in countries like Nepal), even if the surveys were about individual trees or homegardens with trees on what was considered household property, since some of these households influence the management of adjacent community forests (e.g., Oli et al., 2015). I also included other forest management schemes where local communities may have some influence over management, such as participatory forest management systems in Tanzania (Robinson & Lokina, 2011). For the same reason, I included papers on communities with "use-rights" to forests, where smallholders are explicitly allocated areas of state-owned forests to use for a specific bundle of resources (e.g., NTFP), *and* where these use-rights can be transferred in a manner similar to ownership transfer (e.g., Garedew, Sandewall, & Soderberg, 2012). I included these use-rights papers because the exclusive access that this system generates is similar enough to private ownership (at least in the short term) that one might expect purposeful management of these forest areas.

2.2.2. Forest types

Reviewing the literature revealed a wide variety of land use types that I considered to be "forested". Due to the interest in forest gains on abandoned agricultural land (or "deagrarianization"; Shackleton, Shackleton, Shackleton, & Gambiza, 2013), I included papers which discussed land that was owned by family owners or smallholders that might not be considered forested at present, but was likely to be in the near future. I also retained papers on shifting cultivation and the role of forests (managed or natural) or agroforestry practices for provisions of natural resources, as well as papers on plantations (e.g., coffee, rubber, cocoa, palm oil, banana/plantain, bamboo (Lobovikov, Schoene, & Lou, 2012), and homegardens which included the extensive use of trees and shrubs (and thus appearing forested). I excluded papers that focused only on non-woody crops (e.g., corn, sorghum, cassava, etc.). This latter set included studies of risks that a forested landscape represented to smallholders and their non-woody crops (e.g., crop pests and wildlife originating from forests), where the smallholders were not managing the (government or industrial) forests. I also eliminated papers that discussed individual trees on agricultural or suburban and residential properties (most common in the "smallholder" keyword search in the savanna biome, and "household" search for homeowners in residential areas), as well as papers focused strictly on urban forests (which are publicly owned and managed), with the exception of Safransky (2014) on the reforestation of privately-owned parcels by private owners in Detroit (and thus fit into the scheme of small privately-owned forests). I excluded papers that focused solely on the conversion of forest to non-forest (e.g., to agriculture or residential), with no attention to the management of remaining forests by private or communal owners (e.g., Baldwin, Tombulak, & Baldwin, 2009; Kline, Moses, Lettman, & Azuma, 2007).

2.3. Step 3: identification of nodes and paper coding

I created an exclusive EndNote project library for this review and downloaded the pdfs and citations of the included papers into the library, and then imported the entire library into NVivo Plus 11.x64. Using the NVivo "Word Frequency" tool at the setting "with synonyms", I identified ~50 of the most common words across all 456 papers, eliminated years (e.g., 2001, 2002) and irrelevant words such as "percent", "among", "also", etc. by tagging them as "stop words". I ran this Word Frequency query four times in total, each time allowing the software to replace the eliminated "stop words" with additional words. Once finished with this tool, I identified each of these frequent words as nodes (Appendix). Using these nodes, I then started coding the text within the papers, along the way adding three more nodes for words or phrases that were often discussed but did not rise to the level of frequent, but are important emerging issues: "exotic and invasive species", "energy", and "sustainable". I also added "land use" as a single node, which substantially overlapped with the nodes "land" and "use"; however, these two nodes also coded for other concepts so I retained all three as separate nodes. For some nodes, I expanded the original set of synonyms identified by the software into broader concepts (Appendix). For example, I coded all words and phrases that had to do with economic dimensions under the "income" node (e.g., wealth, cost, return on investment, economic, economy, cash, rich, poor). I started by coding papers which had examples over 40 different nodes (often review papers or those with broad scopes), and coded new papers until I could not find any new, relevant words to code (that is, all the relevant words had been automatically coded to a node in each new paper I opened). I coded all the nodes in one sweep per paper, using the "highlight" and "coding stripes" tools in NVivo to allow me to focus on the text of the paper that had not been automatically identified and coded. I then used the AutoCode tool in NVivo on the "by node" and "sentence" settings, using my seed coding from above, to ensure that all 456 papers were coded similarly.

I then sought to collect these nodes into similar groups or themes, to identify emerging trends and issues concerning landscape-level dynamics of family forests. To do this, I used the "Cluster Analysis" tool to assemble groups of nodes by similarity, by choosing the "Word Similarity" and "Pearson correlation coefficient" options to generate a dendrogram where hierarchical distance between each pair of clusters reflected the Pearson correlation coefficient value. (In NVivo, node correlations are measured by the similarity of the collection of words, and number of times each word appears, in the coded text of each node.) Clustering nodes (instead of papers) means that while each node is found in only one cluster, each of the 456 papers can appear in multiple clusters, since one paper can examine multiple topics and thus can be closely associated with more than one node. I used these clusters to drive more in-depth analysis, identifying the top four or five papers in each node (by percent of words coded under that node) and synthesizing those papers collectively under each node cluster. My rationale for this approach assumes that the more times a paper was coded for a specific node, the stronger the paper's focus on that node. For example, a paper in which 20% of the words are coded to the node "plantation" is likely to have a stronger focus on plantations than a paper where 5% of the words are similarly coded. Pulling these top handful of papers and reading them in-depth allowed me to better

identify similarities in focus among the pulled papers for the entire cluster, and thus understand how these nodes were related (e.g., papers discussing "plantations" are quite similar to those discussing "trees" and "forestry", as the forestry profession provides advice and methods for tree planting activities to build plantations). I added a few additional papers to the cluster synthesis in cases where the same paper appeared at the top of the list for more than one node in a cluster.

For the four nodes added after the Word Frequency stage ("energy", "land use", "exotic or invasive", "sustainable"), the AutoCode tool coded by sentence (not by word), and therefore the Cluster Analysis tool lumped these four nodes together since the coding patterns were more similar to each other than with other nodes. For the four nodes in this cluster, I summarized the papers that described these topics in depth (not papers with one or two mentions; I am assuming that word repetition is equivalent to depth of discussion). One of the papers under the "energy" node was a 500+ page report of all forest drivers in the southern United States (Wear & Greis, 2013), so I focused my node synthesis on only the report chapter on bioenergy.

3. Results and discussion

The complete library of relevant and usable papers included 456 papers published between 1991 and the end of 2017 (see Supplemental Online File for a list of all 456 papers). The majority of papers included in this analysis were published after 2005, mostly due to fewer papers published at the landscape scale earlier than this but also due to the lack of enhanced pdf files available for earlier publications (Fig. 1). Over time, the popularity of the top nodes ("land", "use", "area", "study", "agriculture") did not change over time, however some of the less common nodes did change in frequency. More recently, "policy", "sustainable", and "environment" have become more popular topics.

A cluster analysis organizing the papers into clusters of papers by similarity of node coding is available as a Supplemental Online File. In that analysis, the papers are organized by the most commonly coded nodes. This file will be valuable to readers who are interested in identifying papers addressing specific topics, but this analysis does not shed much light on the broad themes emerging from the literature collectively.

3.1. Cluster tree

NVivo identified eleven node clusters, based on the similarity of the coding for each node compared to other nodes (Fig. 2). For example, "biodiversity" and "species" were placed in the same subcluster of Cluster 8 because 1) the same phrases were coded with both nodes, and 2) the word "species" is often used as a qualifier of "biodiversity" (e.g., "species biodiversity", as opposed to genetic or community biodiversity). Each paper could be listed under multiple nodes (and therefore multiple clusters), therefore some clusters demonstrated some overlap in content and main themes.

3.1.1. Cluster 1: data, methods, area, study

This cluster of nodes described methodological issues such as types of data used (e.g., remote sensing, interviews, surveys), types of methods (e.g., supervised classification, mixed methods), and case study locations or regional descriptions. Each of these words were used in almost every paper, often within the same sentences and paragraphs in the "Methods" section, driving the tight grouping of these four nodes as a remote cluster from the rest of the nodes. Given the ubiquity of these four nodes and their tangential relationship to the main focus of this review, I will not discuss this cluster further.

3.1.2. Cluster 2: income, support, household

This cluster was focused on socio-economic issues at the household level which influence production methods and landscape-scale land use patterns. Many of these papers discussed cash crops and non-timber forest products (NTFP), poverty, and sustainable development programs in South America, Africa and Southeast Asia. Stabilizing the value of NTFP often results in an increased perceived value of intact forests to local communities, which provides an incentive to follow sustainable practices (such as agroforestry) and achieve conservation goals (Angelsen & Wunder, 2003; Oestreicher et al., 2014; Wilsey & Hildebrand, 2011). NTFP extraction from community forests is often critical to reduce a household's economic vulnerability during adverse periods (e.g., health events, extreme weather, crop failures, or economic downturns), particularly for poor households (Cotta, 2015; Fu et al., 2009; Völker & Waibel, 2010). However, NTFP extraction is reduced by increased competition with plantations, overharvesting of NTFP, increased distance to markets, decreased distance to forests, and increased off-farm income (Cotta, 2015; Laird, Awung, Lysinge, & Ndive, 2011; Soriano, Mohren, Ascarrunz, Dressler, & Peña-Claros, 2017; Völker & Waibel 2010).

The distribution of a household's subsistence and production activities among NTFP extraction, agriculture, agroforestry, plantations

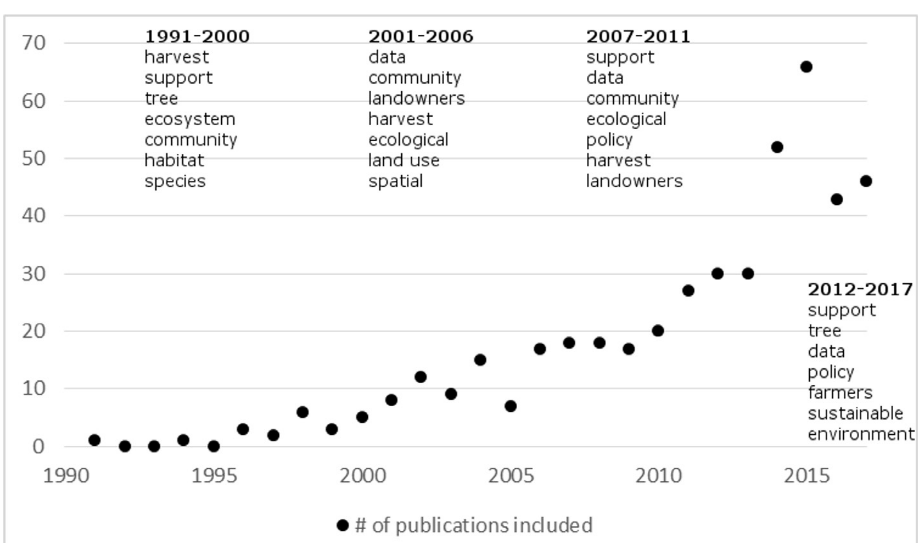

Fig. 1. Number of papers per year included in this analysis, and most commonly coded nodes during each time period (list of common nodes excludes search terms in Table 1, and the following nodes that were the top five nodes in each period: "land", "use", "area", "study", "agriculture", always appearing in that order).

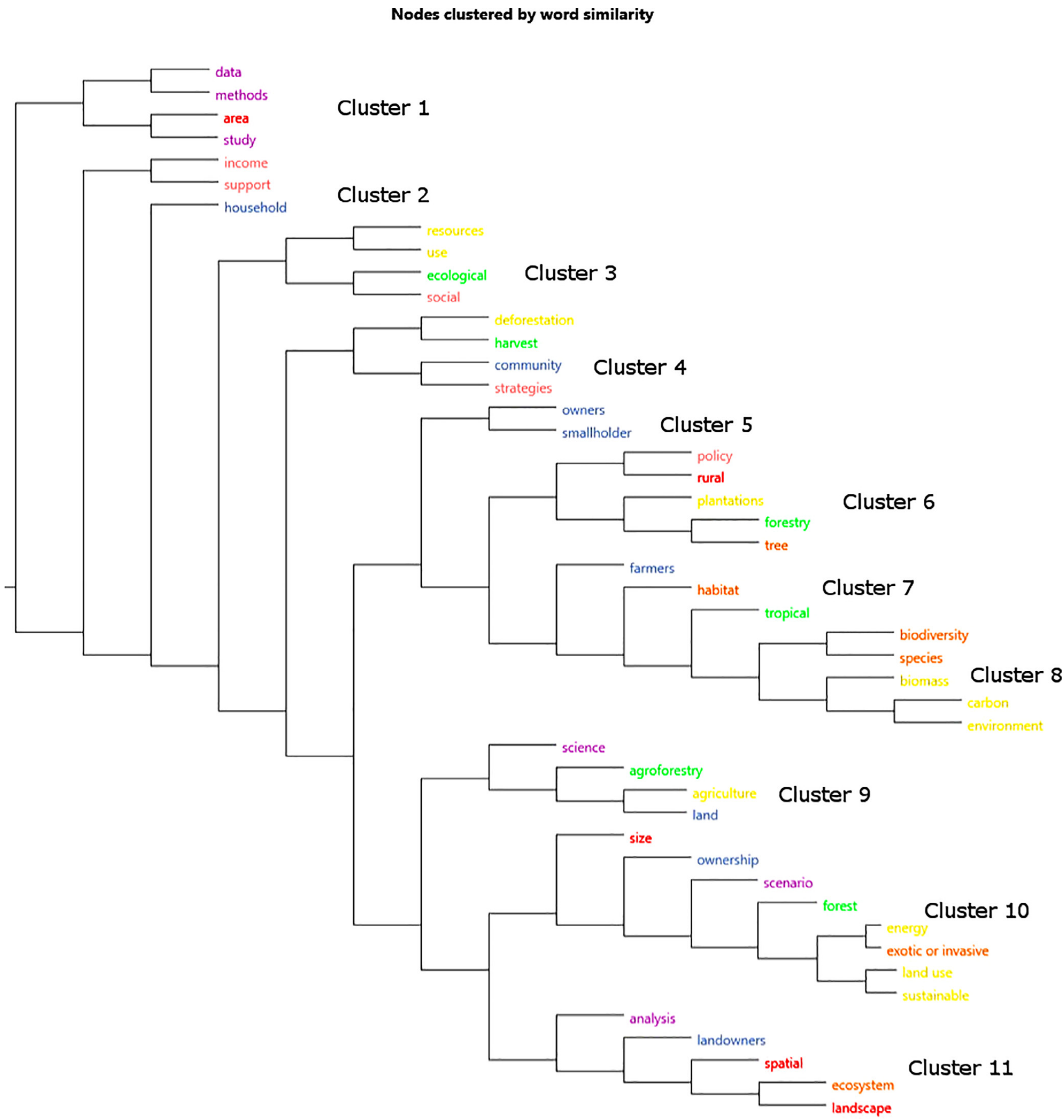

Fig. 2. Cluster tree identifying 11 clusters of nodes with similarly coded papers. Cluster 10 was further separated into two subclusters (#10 and #10a, see text).

and cattle pasturing was determined by several socio-economic factors, including household-level demographics (number of women and children, education level) and larger scale labor migration dynamics (Oestreicher et al., 2014; Radel et al., 2010; VanWey, D'Antona, & Brondízio, 2007). Generally speaking, better access to capital (through off-farm income or remittances or government support programs) increases the likelihood that households prioritize long-term and capital-intensive land uses such as timber or crop plantations and cattle pasturing, often resulting in natural forest loss and fragmentation (Palacios et al., 2013).

Global trends impacting land use choices (and thus forest degradation) include climate change, market globalization (and cash crop price volatility), civil conflicts, and population growth. All of these place extreme pressure on local and regional forest resources and can drive deforestation or conversion of natural forests to plantations (Palacios et al., 2013; Sandewall et al., 2015; Soriano et al., 2017). Economic inequality also drives patterns in land abandonment (and reforestation) and speculation (often driving deforestation or conversion to plantations; Sreeja et al., 2015). Eucalypts, *Acacia*, rubber and palm oil are commonly-discussed timber and cash crop plantation species, but these species are often exotics and generate ecological concerns, particularly over water supplies where these trees are planted (Sandewall et al., 2015).

3.1.3. Cluster 3: resources, use, ecological, social

This cluster discussed the challenges of achieving ecological targets

for public goods (such as forest cover or biodiversity conservation) in landscapes where there are high proportions of private or communal forest owners, where land tenure is complicated or less than secure, and where the participation of communal or private owners is required to meet those targets.

One set of papers discussed incentive program efficacy for biodiversity conservation on privately owned forests, primarily in developed countries where land tenure was clearly established. For example, several papers measured the value of landscape diversity to the general public, in the form of willingness to pay for incentives to private owners to engage in conservation easements (i.e., to be compensated for foregoing development or other habitat destroying actions; Kurttila & Pukkala, 2003; Matta, Alavalapati, & Tanner, 2007). Conservation goals were best achieved by identifying areas of high ecological quality owned by landowners who were sympathetic to biodiversity conservation, and who were receptive to reasonable compensation and learning about management activities to enhance biodiversity on their property (Deconchat et al., 2007; Milne & Bennett, 2007). These compensation schemes often target conservation in rural areas, and thus need to account for the higher willingness to pay for conservation by urban residents due to income differences and also higher support for environmental protection (Shi et al., 2016). Rural forest owners may have little awareness of the broader public good or "social values" of landscape-scale forests, and perhaps not much interest. Family forest owners are often driven to prioritize personal social values of their forests, such as traditional activities like recreation, "heritage" values and privacy (Bjärstig & Kvastegård, 2016; Lind-Riehl et al., 2015). Harmonizing program goals reflecting social or public goods with forest owner goals is necessary for program success.

Owner characteristics such as migration status and land tenure have a profound impact on landscape scale forest cover and biodiversity (Asare et al., 2013; Toledo-Hernández et al., 2016). Recent migrants often have different land management practices from residents or historic migrants, and the diversity of these practices at the scale of the homegarden or smallholdings can aggregate into large influences on the flora and fauna in the landscape (Lambin et al., 2001; Oestreicher et al., 2014; Toledo-Hernández et al., 2016). Clear land tenure is extremely important for stabilizing forests and policy effectiveness, although with the caveat that privatizing is not always beneficial (Asare et al., 2013; DiGiano et al., 2013; Sandewall et al., 2015). After 1992 Mexican policy reforms allowed communal ejidos to split their land into individual parcels (which could then be removed from the ejidos, and thus privatized), deforestation was higher in former ejidos which parcelized their holdings into individual private forests, versus in ejidos which retained their communal ownership and management (DiGiano et al., 2013). Likewise, simulations on forest cover in Appalachia identified higher land use variability and more forest loss on private lands, much of it due to residential development and roads (Wear et al., 1996).

3.1.4. Cluster 4: deforestation, harvest, community, strategies

Papers in this cluster discussed deforestation and harvesting rates and practices, along with strategies and policies to bring these negative trends under control. The papers were split between a focus on individual versus community forests, with case studies representing both developing and developed countries.

Both smallholders and large industrial actors have driven deforestation in the Amazon region. In Brazil, national forest conservation policies and better monitoring (using remote sensing) have dramatically reduced the size of deforested patches. While this might suggest that smallholders were increasingly responsible for deforestation, it is equally likely that large industrial actors were operating in smaller patches to comply with the new laws (Godar, Tizado, & Pokorny, 2012; Rosa, Souza, & Ewers, 2012). Deforestation rates are also higher in Brazilian states where land tenure is less secure, particularly when clearing forest remains a recognized way to assert tenure rights and forest is not considered a "productive use" of land (Araujo, Bonjean, Combes, Motel, & Reis, 2009). The Sustainable Development Goals (SDGs) may provide opportunities to push for community-based sustainable forestry in developing countries (de Jong et al., 2016). Many of the SDGs focus on known deforestation drivers, such as poverty, socioeconomic inequality, food and resource insecurity, and advance policy solutions that focus on forests and the goods and services they provide. Sustainable forestry programs implemented by non-governmental organizations and forestry professionals can help communities diversify their forests and forest products, and harmonize REDD+ strategies with SDG programs (Barsimantov, 2010; Pacheco, 2012).

In the United States and Canada, urban sprawl pressures dramatically increased conversion to non-forest land uses (McDonald et al., 2006); increases in stumpage prices and harvesting incentives are not likely to offset the steeply rising residential prices that drive forest lost to sprawl. However, when harvesting did occur on family forests, their selective harvest methods had little impact on long-term biodiversity (McDonald, Motzkin, & Foster, 2008). While difficult to detect and monitor, these selective harvests represent a sizable disturbance in these landscapes; family forests represented 60% of the forested area and 64% of the harvests (Kittredge, Finley, & Foster, 2003). Policies governing harvest methods should require better monitoring, and use conservation easements and other incentive programs to keep the region forested and protect biodiversity (Kittredge et al., 2003; McDonald et al., 2008; Schwan & Elliott, 2010).

Finally, one group of papers was an interesting mix of studies from developed and developing countries, which investigated alternative strategies to boost goods and services from forests in a sustainable manner. In Finland, where "Everyman's Rights" grants non-destructive use of private forests to the public, social norms heavily influenced the kinds of relationships that nature tourism operators maintained with forest owners, some of which may not be sustainable (Matilainen & Lähdesmäki, 2014). In Indonesia, Law et al. (2017) considered a variety of policy scenarios advocating land sparing, land sharing, or mixed approaches to maximize the production of goods and services while preserving biodiversity. In Central America, adjustments to planting schemes at the stand (e.g., tree species mixes, insecticides) and landscape level (relying on forest regeneration of small patches from adjacent natural forests) generated the greatest productivity boost to reforested former pastures (Riedel, Dorn, Plath, Potvin, & Mody, 2013). And in Ethiopia, the interaction between social forces (such as population growth, shrinking smallholder size and incomes) and environmental consequences (deforestation, land degradation) emphasized the critical need for policies that address deforestation and socioeconomic pressures simultaneously (Garedew et al., 2012). All of these papers emphasized the necessity of new policies, or enforcement of existing regulations, to reduce conflicts among stakeholders in forested landscapes and maximize the production of forest goods and services for all.

3.1.5. Cluster 5: owners, smallholders, ownership

Among the papers that had the highest frequency of coded text for these nodes within them, three topics stood out: ownership typologies in developed countries; sustainable palm oil production by smallholders in tropical countries; and either simulations or historical measurements of landscape-scale forest change, as influenced by ownership type or change (such as parcelization and privatization). While papers on sustainable palm oil may seem like an odd grouping with forest owner motivations in developed countries and land tenure changes in ejidos, all of these papers are connected by similar underlying concerns. Chief among them are how owner or smallholder motivations are affected by socioeconomic and policy drivers, particularly as they relate to forest change (either deforestation or reforestation). Some of these papers also appear in adjacent clusters, such as Cluster 4 ("deforestation") and Cluster 6 ("policy"), highlighting a broad area of interest involving the influence of owner or smallholder behavior through policy levers to manage rates of forest loss or gain.

Information gathered from or about family forest owners can

identify categories that define land management goals and influence decision making (Butler & Leatherberry, 2004; Kittredge, 2004; Law & McSweeney, 2013; Põllumäe, Korjus, & Paluots, 2014; Urquhart & Courtney, 2011). Common motivations for forest ownership and management include conservation (for biodiversity, "nature", or other environmental values), personal privacy and recreation, non-timber extractive uses (such as NTFP or hunting), economic investment, and as part of a legacy for heirs or preservation of history. Ownership motivations guide management decisions (e.g., harvesting, selling part or all of the property, or developing into non-forest land uses), often without consideration for the larger scale public goods that these forests provide (Kittredge, 2004). Land management agencies concerned for the landscape-scale impacts of private decisions on public goods need to offer a variety of programs and outreach techniques in order to appeal to the wide diversity of owner types and motivations (Põllumäe et al., 2014; Urquhart & Courtney, 2011). To date, most policies for family forest owners in developed countries are undersubscribed, and given the high turnover and increase in number of new forest owners expected in the next few decades, policies must be designed to be a better match for ownership needs and goals (Butler & Leatherberry, 2004; DiGiano et al., 2013; Põllumäe et al., 2014).

Another group of papers used historic data to measure trends in forest cover correlated with ownership characteristics change, and simulations of landscape change predicted due to future expected changes in ownership characteristics (Haines, Kennedy, & McFarlane, 2011; Mayer & Rouleau, 2013; Wear et al., 1996). The majority of these papers focused on developed countries, however DiGiano et al.'s (2013) paper on forest cover change and privatization of ejidos was also included in this cluster. Simulations revealed that ownership demographics and information flow (peer to peer) measurably influence forest cover, patchiness and connectivity of forested landscapes (Mayer & Rouleau, 2013; Wear et al., 1996). Historic data on forest cover and ownership revealed clear changes in landscape-scale forest cover due to parcelization (including privatization of individual holdings in ejidos), and when compared across different categories of owners where "categories" were public, industrial, and non-industrial owners (Turner et al., 1996); new owners of parcelized holdings versus owners of intact (non-split) holdings (Haines et al., 2011); or individual versus communal (ejidos) owners (DiGiano et al., 2013). In particular, the parcelization of forest properties in the US, and splitting of communal ejidos into individual private ownerships in Mexico, is increasing the number of family forest owners and the complexity of forest change (Butler & Leatherberry, 2004; DiGiano et al., 2013; Ellis, Romero Montero, Hernández Gómez, Porter-Bolland, & Ellis, 2017; Kilgore, Snyder, Block-Torgerson, & Taff, 2013; Kittredge, 2004). Parcelization greatly increases the risk of deforestation, landscape fragmentation, and residential development (DiGiano et al., 2013; Haines et al., 2011).

A final group of papers focused on the production of oil palm by smallholders, the current impact it has on environmental, social, and economic conditions, and whether policies and certification schemes can make smallholder production more sustainable. Changes in policy and certification schemes that would better incentivize biodiversity conservation, job creation, and social equality are needed in most tropical countries (Azhar, Saadun, Prideaux, & Lindenmayer, 2017; Lee, Garcia-Ulloa, Ghazoul, Obidzinski, & Koh, 2014). In many tropical countries, negative impacts on biodiversity are lower from oil palm production on smallholder properties (compared to large industrial plantations), especially when produced using mixed-cropping agroforestry methods (Azhar et al., 2017). Smallholders represent the front line of suffering from the negative influences of climate change, poverty migration, food shortages, and globalization of markets, and thus deserve more attention and support from policy makers (Pokorny & de Jong, 2015).

3.1.6. *Cluster 6: policy, rural, plantations, forestry, tree*

This cluster examined policy and forest management options that often yielded gains in multiple dimensions, such as biodiversity conservation, rural development, and natural resource management. One group of papers explicitly focused upon the efficacy of forest protection policies aimed at smallholders and family forest owners in developed and developing countries. Comparing plantations across four countries (Ethiopia, China, Vietnam, and Sweden), Sandewall et al. (2015) recommended policy enhancements for clarifying and strengthening land tenure, developing markets for diverse forestry products, and enhancing institutions and their ability to enforce laws and support policies. Tenure systems which codify communal management of forests, and payment for ecosystem services programs, were quite effective at reducing deforestation risks, while agricultural subsidies often drove deforestation, sometimes in favor of plantations (DiGiano et al., 2013; Fischer & Bliss, 2009; Min-Venditti, Moore, & Fleischman, 2017). However, payment schemes require clear property rights and strong government institutions to effectively implement them.

Rural areas around the world are in transition. Smallholder land use transitions include shifts among stages based on wealth and resource access: basic persistence, sustainable subsistence, agricultural diversification and intensification, abandonment, and speculation (Sreeja et al., 2015). Forest management decisions in rural areas influence landscape-scale biodiversity and invasive species spread (Rai, Scarborough, Subedi, & Lamichhane, 2012; Tolera, Asfaw, Lemenih, & Karltun, 2008; Tscharntke et al., 2015). The diversity of direct benefits that rural forests can provide to urban residents, such as mental health therapy and nature education, are dramatically reduced when rural areas depopulate or industrialize (Ohe, Ikei, Song, & Miyazaki, 2017). Plantations of fast-growing exotics are a critical component of rural development in many parts of the world, and the ways that family forest owners utilize them can have substantial impacts on farm- and village-level economic stability, as well as landscape-level impacts on biodiversity and ecological processes (Grossman, 2015; Sandewall, Ohlsson, Sandewall, & Viet, 2010; Su, Zhou, Wan, Li, & Kong, 2016; Wood, Rhemtulla, & Coomes, 2016). Plantations expand fastest in areas where market access is simplified by infrastructure and proximity, and in nations where rural development policies subsidize them (Sandewall et al., 2010; Su et al., 2016). More research is needed at landscape and regional scales to understand how these rural land use transitions influence the ecology, culture, and economy of rural areas, particularly in the context of industrialization and globalization of forest product markets (Bliss, 2003).

3.1.7. *Cluster 7: farmers, habitat, tropical*

This cluster emphasized farm-level management practices that have broader level impacts on climate change and biodiversity conservation. While afforestation schemes in Ireland and carbon sequestration payments in Uganda held promise for climate change mitigation strategies, the complexity of smallholder motivations and policy approaches leave considerable room for improvement (Duesberg, Dhubháin, & O'Connor, 2014; Nakakaawa, Aune, & Vedeld, 2010). Conversely, smallholders in Ghana are switching from lower yield but higher return cocoa plantations to cereals as a recent climate change adaptation strategy, to adjust to more variable weather and rainfall (although some have switched back to cocoa for economic reasons; Asante, Acheampong, Kyereh, & Kyereh, 2017). Asante et al. (2017) also detected higher carbon storage on plots with higher tree diversity, signaling a potential synergy between carbon sequestration schemes and biodiversity conservation. Other smallholder practices which increased farm-scale biodiversity included maintaining some forest in slash-and-burn routines, increasing fallow periods, boosting understory diversity in monocultures with assisted regeneration of wind-dispersed species and large-seeded species, and favoring coffee and timber plantations (over crops and pasture) which act as habitat corridors between natural forest fragments (Hartter, Lucas, Gaughan, & Aranda, 2008; Norfolk et al., 2017; Rocha, Virtanen, & Cabeza, 2015; Willis, Herbohn, Moreno, Avela, & Firn, 2017), although plantations may not reduce hunting pressure on local

biodiversity (Parry, Barlow, & Peres, 2009). Although the papers on forest owners in Ireland and Nordic countries were not coded with the "tropical" node, they did share an emphasis with papers on tropical case studies on reforestation incentive schemes for farmers to either provide habitat or to mitigate carbon emissions, and hence these nodes were placed in the same cluster. This appears to be a common bureaucratic response to biodiversity loss and climate change worldwide.

Matching appropriate policies to smallholder preferences and parcel characteristics is important for effective policy implementation. In Ireland, monetary incentives for afforestation did not appeal to farmers who did not manage their land for profit maximization; capacity-building and public relations approaches may draw in more farmers to the effort (Duesberg et al., 2014). In India, strengthening the ability of communal forest members to exert usufruct rights over their forests could reduce unsustainable resource extraction from these forests by site dwellers outside of the commune (Sinu, Kent, & Chandrashekara, 2012). In Nordic countries, habitat conservation schemes need to determine when and whether contacting targeted landowners with key habitats on their parcels is more efficient than contacting a broader swath of owners (Carlsson, Andersson, Dahlin, & Sallnäs, 1998; Lindbladh, Felton, Trubins, & Sallnäs, 2011).

3.1.8. Cluster 8: biodiversity, species, biomass, carbon, environment

Decisions that smallholders and private forest owners make regarding the use or support of biodiversity and carbon sequestration on their own properties can either complement or degrade biodiversity and climate mitigation efforts at landscape and regional scales (Boffa, Kindt, Katumba, Jourget, & Turyomurugyendo, 2008; Nordén, Coria, Jönsson, Lagergren, & Lehsten, 2015; Schmitt-Harsh, Evans, Castellanos, & Randolph, 2012; Tscharntke et al., 2015; Wulf & Kolk, 2014). Conversely, biodiversity directly benefits smallholders and forest owners in many ways, especially when producing a variety of timber, NTFP, food crops, and carbon offsets (Nakakaawa et al., 2010; Nath, Nath, Sileshi, & Das, 2017; Sunderland, 2011). Policies aimed at incentivizing certain activities on smallholder or family forests (for biodiversity conservation or carbon sequestration) need to be tailored to these forest owners, not simply aggregated into broad policies that are often more attractive to large and industrial landholders.

The historical tenure and socioeconomics of smallholders directly factor into the amount and kinds of biodiversity supported on private or communal forests and thus contributed to forested landscapes (Boffa et al., 2008; Pinard, Joetzjer, Kindt, & Kehlenbeck, 2014; Tolera et al., 2008; Wulf & Kolk, 2014). This contribution to landscape-scale biodiversity support can be compensated when the general public values biodiversity conservation higher than family forest owners (Górriz-Mifsud, Varela, Piqué, & Prokofieva, 2016; Nordén et al., 2015). Owners and smallholders could either be compensated directly by government programs, or through certification schemes for cash crops such as shade coffee and cocoa (Tscharntke et al., 2015). Di Giminiani (2016) described a cautionary case study of the costs (in terms of biodiversity loss and deforestation) that come with ignoring smallholders in policy and governance decision-making.

One group of papers in this cluster focused on biomass harvesting for bioenergy, biomass as a sink for carbon (even in plantations), and smallholder participation in carbon markets (Kuyah, Dietz, Muthuri, van Noordwijk, & Neufeldt, 2013; Kuyah & Rosenstock, 2015; Nath et al., 2017; Schmitt-Harsh et al., 2012). Tree diversity had a positive relationship with carbon density at the plot level, suggesting that management decisions by smallholders will be important to influence to maximize carbon offsets as an income stream (Nakakaawa et al., 2010; Nath et al., 2017). If carbon offset markets are intended to also help alleviate poverty, programs will need project brokers to mitigate the scale mismatch between the buyers of carbon offsets on long-term global markets, and the producers of carbon offsets by smallholders making plot-level decisions on short time scales (Lee, Ingalls, Erickson, & Wollenberg, 2016). Carbon sequestration policies also need to consider how compensation programs may discriminate against poorer smallholders and generate non-optimal spatial patterns of forest protection for sequestration and deforestation (Eloy, Méral, Ludewigs, Pinheiro, & Singer, 2012). In the US, carbon markets could be used to identify the per-ton price for carbon necessary to stabilize forest cover and carbon stocks (Latta, Adams, Bell, & Kline, 2016). However, a family forest owner's willingness to harvest biomass for bioenergy was highly variable across owners and states, depending upon the owner's attitudes regarding harvesting, and was not very responsive to price (Cai, Narine, D'Amato, & Aguilar, 2016; Markowski-Lindsay et al., 2012). Given this variability, bioenergy policies focused on family forests should be tailored at the state level.

3.1.9. Cluster 9: science, agroforestry, agriculture, land

In developing countries, agriculture is the primary driver of deforestation, responsible for almost three-quarters of forest loss in recent decades (Hosonuma et al., 2012). Much hope has been placed on agroforestry to lighten the impact of productive land uses on forests. In the past, there has been a paucity of scientific research on the impact of agroforestry practices on landscape-scale patterns and processes, particularly carbon sequestration, water quality, and biodiversity conservation (Nair, 1998). These papers discussed the application of science to improving agroforestry and homegarden practices, and understanding their advantages to smallholders and their large-scale impacts, both positive and negative (Allen, Corre, Kurniawan, Rahayu Utami, & Veldkamp, 2016; Rocha et al., 2015; Thongmanivong & Fujita, 2006; Tolera et al., 2008; Turner, 2010). Throughout the tropics, agroforestry practices have been demonstrated to significantly assist smallholders with climate change adaptation, improved soil fertility and conservation, pest and disease control, income diversification, and offset fuelwood collection from natural forests, although agroforestry practices have been unable to match natural forests in carbon sequestration potentials (Carlson, Mitchell, & Rodriguez, 2011; Lasco, Delfino, & Espaldon, 2014; Mbow, Smith, Skole, Duguma, & Bustamante, 2014).

However, understanding the impediments facing landowners around the world regarding agroforestry and reforestation programs is critically important. In Ireland, one of the barriers to enrollment in afforestation programs has been the greater value placed on land for food production (Duesberg, O'Connor, & Dhubháin, 2013). Agroforestry approaches may be successful in balancing these two values (food production and reforestation), however agroforestry in developed countries was rarely if at all discussed in this collection of papers. The diversity of socioeconomic status, land tenure stability, and preferences regarding land use and production not only influences landscape-scale land use and land cover patterns, but has long-term influences on these patterns that echo from past to present (Boutthavong, Hyakumura, Ehara, & Fujiwara, 2016; Coomes, Takasaki, & Rhemtulla, 2016; Donnelly, 2011).

3.1.10. Cluster 10: size, ownership, scenario, forest

I coded all land tenure and access issues into "ownership", as well as ownership change processes including parcelization or splitting landholdings among multiple heirs. Therefore, this node was characterized by papers which discussed privatization schemes, and parcelization or farm-splitting trends which created forested landscapes with many owners of smaller parcels (DiGiano et al., 2013; Haines et al., 2011; Ko & He, 2011; Ko, He, & Larsen, 2006; Kilgore et al., 2013; Wear et al., 1996). When deforestation or forest fragmentation occurred, it was often during periods of ownership fragmentation, caused by land use transitions to either agriculture (in developing countries) or urbanization (in developed countries), both driven by population growth (Haines et al., 2011; Wear et al., 1996). However, in the Missouri Ozarks (USA), some ownership aggregation has also occurred (Ko & He, 2011).

Computer models generated multi-scale scenarios to help local stakeholders understand the impact of large scale dynamics (global

markets, national policy, ecosystem services) on local socioeconomic decision making (Dermawan, Kemp-Benedict, Huber-Lee, & Fencl, 2013; Hengeveld, Schull, Tubins, & Sallnas, 2017). Smallholder decisions included: tree plantation management (Dermawan et al., 2013), suitability of incentive payments for ecosystem services from society to private forest owners (Górriz-Mifsud et al., 2016), or prioritization of income-generating versus ecosystem service-generating forest management (Mozgeris, Brukas, Stanislovaitis, Kavaliauskas, & Palicinas, 2017). Historic forest cover data, combined with mixed-methods social science data, emphasized the diversity of forest owner priorities, knowledge about forest management, attitudes towards forests, and contribution of private forests towards forest conservation (Bürgi, Steck, & Bertiller, 2010; Dhubháin, Maguire, & Farrelly, 2010; Upton, Dhubháin, & Bullock, 2015).

3.1.11. Cluster 10a: energy, exotic-invasive, land use, sustainable

The Cluster Analysis placed these four nodes in one sub-cluster, due to being coded by sentence rather than by word. Although this subcluster most closely aligned with the forest ownership cluster (#10), I will discuss these four nodes as a separate subcluster here.

3.1.12. Energy

Sourcing renewable energy in ways that are carbon neutral and economically feasible requires woody biomass harvesting close to points of production or use (Brunner, Currie, & Miller, 2015; Creutzburg, Scheller, Lucash, & Evers, 2016; Wear & Greis, 2013). Given the large percentage of forested landscapes under family forest owner control, the availability of this woody feedstock for energy production naturally requires harvesting family-owned forests (Cai et al., 2016). The likelihood of family forest owners in developed countries providing biomass for bioenergy production is dependent upon their ownership motivations and attitudes towards bioenergy (Blennow, Persson, Lindner, Faias, & Hanewinkel, 2014; Brunner et al., 2015; Dorning, Smith, Shoemaker, & Meentemeyer, 2015). Certification schemes for forest-based bioenergy will need to better account for harvesting and production impacts on biodiversity, soil fertility, water quality, and landscape-scale effects (Wear & Greis, 2013).

3.1.13. Exotic-invasive

An interesting division was evident in papers discussing exotic versus invasive species beyond a casual mention. One group of papers discussed the costs and benefits of exotic shrub and tree species use in agroforestry systems, which are increasingly common for both timber and NTFP production for smallholders in tropical countries (Dawson et al., 2011, 2013, 2014). Widespread plantation species such as eucalypts, *Pinus*, *Grevillea*, *Cupressus*, and non-timber plantation species such as shade coffee, fruit trees, tea and medicinals contributed positively to productivity and smallholder livelihoods in agroforestry and homegarden systems in many developing countries (e.g., Acheampong, Insaidoo, & Ros-Tonen, 2016; Boffa et al., 2008; Kabir & Webb, 2008; Moreno-Calles, Casas, García-Frapolli, & Torres-García, 2012). Several papers did examine potential negative impacts of the use of exotics in these systems, particularly on local and regional biodiversity, and on the domination of these exotics over native species in the future (Armesto, Smith-Ramirez, & Rozzi, 2001; Haile, Lemenih, Senbeta, & Itanna, 2017; Nakakaawa et al., 2010; Norfolk et al., 2017; Pinard et al., 2014). Only two papers examined the role that plantations of exotic species play in non-industrial forestry in developed countries (New Zealand and Belgium; Hawes & Memon, 1998, Van Gossum, Luyssaert, Serbruyns, & Mortier, 2005).

Conversely, almost all the papers discussing invasive species with any depth focused on case studies in developed countries, and usually on non-woody plants, insect pests, and pathogens. A cluster of papers discussed management strategies and policies for invasive species control on family forests in the United States (Fischer & Bliss, 2008; Fischer & Charlney, 2012; Gass, Rickenbach, Schulte, & Zeuli, 2009; Law & McSweeney, 2013; Matta et al., 2007; Rickenbach, Guries, & Schmoldt, 2006; Rouleau, Lind-Riehl, Smith, & Mayer, 2016; Wear & Greis, 2013), or on the drivers of invasive species spread into family forests (BenDor, Shoemaker, Thill, & Dorning, 2014; McDonald et al., 2008). Only three papers investigated the risk, benefits, or management of invasive species in developing countries (Brazil, Nepal, and South Africa; Rai et al., 2012; Shackleton et al., 2013; Walker, Moran, & Anselin, 2000).

3.1.14. Land use

This phrase was extremely common, present in almost every paper and used in the title of 25 papers. The vast majority of these papers dealt with land use transitions to or from forest, especially forest to agriculture, plantations, or agroforestry, and many examined the role of landowner behaviors, motivations, and values in the probability of land use change (e.g., BenDor et al., 2014; Chen & Nakama, 2015). A few papers examined broader drivers of forest loss and fragmentation, such as privatization and parcelization (Haines et al., 2011). Perhaps uniquely, Safransky (2014) discussed the impact of reforestation policies in neighborhoods of shrinking cities dominated by vacant lots on remaining landowners, and the echoes of colonial practices (such as land appropriation) in reforestation policies.

3.1.15. Sustainable

Papers concerned with sustainability or sustainable management often discussed trade-offs among economic and environmental outcomes (Bawa & Seidler, 2015; van Noordwijk, Suyamto, Lusiana, Ekadinata, & Hairiah, 2008), or conversely the synergistic outcomes between these two dimensions (Zobrist, Gehringer, & Lippke, 2004). For example, Mertz et al. (2012) examined how avoided forest degradation incentivized under REDD+ can increase carbon sequestration, preserve biodiversity, and support local livelihoods by diversifying landowner production, particularly using sound agroforestry practices and plantations in less productive areas that do not replace natural forests (Hawes & Memon, 1998; Mbow et al., 2014; Sandewall et al., 2015). In developing countries, multi-use and mixed-use forest management and monitoring approaches (at both the forest and the landscape scale), along with agricultural intensification (land sparing), can slow deforestation and improve smallholder livelihoods (Bawa & Seidler, 2015; Bullock, Mithöfer, & Vihemäki, 2014; Rahman, Sunderland, Roshetko, & Healey, 2017; Rosa, Bonham, Dempewolf, & Arakwiye, 2017). To be successful, many approaches to sustainable forest management require secure land tenure and smallholder access to markets (Mertz et al., 2012; Sandewall et al., 2015).

3.1.16. Cluster 11: ecosystem, landscape, spatial, landowners, analysis

Papers under the “ecosystems” and “landowners” nodes focused on the trade-offs among ecosystem services, particularly between production of timber and other products versus cultural or regulating services such as recreation or carbon sequestration. Ownership type and owner values influence which ecosystem services are prioritized; forest ownership motivated by recreation and hunting often prioritize wildlife habitat and conservation, and might be more amenable to carbon sequestration programs than owners motivated by timber production, for example (Fries, Carlsson, Dahlin, Lämås, & Sallnäs, 1998; Kaetzel, Majumdar, Teeter, & Butler, 2012; Khanal et al., 2017; Plieninger, Ferranto, Huntsinger, Kelly, & Getz, 2012; Tadesse, Zavaleta, Shennan, & FitzSimmons, 2014). In particular, the cultural value placed on different ecosystem services by forest owners scale up to inform landscape planning, occasionally at the expense of landscape-scale biodiversity conservation (Plieninger et al., 2015).

Studies in the “landscape”, “spatial” and “analysis” nodes sought to clarify processes and metrics of landscape patterns, such as parcelization (Haines et al., 2011; Kilgore et al., 2013), distinction of management practices leading to forest degradation (McCracken et al., 1999), and tipping points for biodiversity loss and deforestation (Ochoa-

Quintero, Gardner, Rosa, de Barros Ferraz, & Sutherland, 2015; Tolera et al., 2008). Vokoun, Amacher, Sullivan, and Wear (2010) and Aguilar, Cai, and Butler (2017) demonstrated the influence of adjacent forest owner behavior on family forest owner decision making, thus raising the opportunity to incentivize forest owner cooperation to achieve landscape-scale goals and optimize habitat conservation planning (Kurtilla, 2001). However, incentive programs are more likely to be successful (e.g., create a connected mosaic of forests in a landscape) if the programs allow some autonomy for land management decisions (Sorice et al., 2013).

4. Broader themes and future directions

Several themes appeared repeatedly in the cluster analysis, signifying active areas of research. In developing countries, land tenure security and clear access to resources profoundly improves landscape-scale forest cover and biodiversity (Clusters 3, 4, 6, 10; DiGiano et al., 2013; de Jong et al., 2016; Pacheco, 2012; Sinu et al., 2012). Whether for households or communes, stable land tenure substantially increases the use of sustainable agricultural, agroforestry, and forest extraction practices (Völker & Waibel, 2010). Conversely, where land tenure is tenuous and where government incentives encourage labor migration (in either direction), deforestation rates are higher (Barbieri & Carr, 2005; Lambin et al., 2001; Meyfroidt et al., 2010; van Noordwijk & Villamor, 2014; Radel et al., 2010; Rudel et al. 2005; Sharma et al., 2015; Turner, 2010). Landscape-scale land use change as a result of increased capital sent home from migrant works has been described as "remittance landscapes" (Clusters 2 and 3; Hostettler, 2007; Lopez, 2015). Weak forest conservation laws and lack of regulatory enforcement contributes to higher deforestation rates by both smallholders and large industrial actors (Cluster 4; Godar et al., 2012; Rosa et al., 2012). Whether for forest protection, climate change mitigation, or biodiversity conservation, policies aimed at smallholders in developing countries will be ineffective without concurrent improvements in cadaster and land tenure systems.

Parcelization and privatization is creating many more smallholders and family forest owners on forested landscapes in all nations, and in many areas is at least an indirect driver of deforestation (Clusters 5, 10, 11; DiGiano et al., 2013; Haines et al., 2011; Kilgore et al., 2013; Ko & He, 2011; Thongmanivong & Fujita, 2006), except where deforestation is prevented via strongly enforced laws (e.g., in Europe). Deforestation in the wake of forest division is not inevitable, however. As stated above, securing land tenure rights and access to resources, as well as promoting sustainable agroforestry and agricultural intensification practices, can provide subsistence resources and cash crops to secure smallholder livelihoods, Where land tenure is secure, forest conservation incentive policies targeting family forest owner motivations and goals can maintain forest cover and functionality.

Indeed, given the commonalities in deforestation trends and drivers across regions and societies, it was surprising that I found only one comparative paper at the international scale (Sandewall et al., 2015). However, this review revealed important similarities among otherwise different forest ecosystems and cultures, such as: the impact of NTFP harvesting on forest resources and biodiversity (Clusters 2 and 8; Cotta, 2015; Soriano et al., 2017; Sunderland, 2011; Völker & Waibel, 2010); the potential for ecotourism in private forests to provide economic support to forest owners (Cluster 4; Matilainen & Lähdesmäki, 2014; Ohe et al., 2017; Watson, 2017); and the risks and benefits of plantations of fast-growing exotics to natural forests within forested landscapes (Clusters 6 and 10; Hawes & Memon, 1998; Grossman, 2015; Sandewall et al., 2015; Su et al. 2016; Van Gossum et al., 2005). Government policies encouraging reforestation on small farms for biodiversity conservation and climate mitigation have met with similar hesitancy by both Irish and Ugandan farmers (Cluster 7; Duesberg et al., 2014; Nakakaawa et al., 2010). These farmers may be responding to similar opportunity costs (foregoing profitable crops) or social barriers (cultural expectations that landscapes remain "open" (i.e., not forested)). Labor migration affects land management choices in both source and host countries, binding the fate of these distant forested landscapes (Clusters 2 and 3; Lambin et al. 2001; Oestreicher et al. 2014; Su et al. 2016; Toledo-Hernández et al. 2016). Family forest owners everywhere are increasingly encouraged to produce biomass for bioenergy (Clusters 8 and 10; Blennow et al., 2014; Brunner et al., 2015; Cai et al., 2016; Dorning et al., 2015; Markowski-Lindsay et al., 2012), often for foreign markets (Goh et al., 2013). Simultaneously, many are also encouraged to sequester carbon and participate in carbon offset markets (Clusters 7–11; Lee et al., 2016; Nakakaawa et al., 2010; Nath et al., 2017; Schmitt-Harsh et al., 2012). Whether both of these goals can be achieved on family forests at any scale is an important but unanswered question.

What this collection of literature did highlight was the growing connectedness of forested landscapes and communities across the world through long-distance feedbacks ("teleconnections" or "telecoupling"; Friis et al., 2016). Deforestation of the tropics lies at the nexus of poverty, colonization, and globalization (Rudel; 2015); while forests elsewhere recover as populations leave rural areas for urban ones, high-income nations invest in forested landscapes while sourcing consumer products and food from developing countries (Meyfroidt et al., 2010; Shackleton et al., 2013). These processes of urbanization and globalization operate across multiple scales, impacting family forest owners who respond through forest management decisions that aggregate into deforestation and degradation, or reforestation, driving changes in global climate and regional biodiversity (Dermawan et al., 2013). The role of policy leakage in deforestation and reforestation patterns is not yet thoroughly understood, nor are commonly-held perceptions about the role of family forest owners and smallholders in large-scale forest cover change (Delacote, Robinson, & Roussel, 2016; Henders & Ostwald, 2014; Law & McSweeney, 2013).

This collection of papers provides many examples of policies which address cross-scale drivers, linkages, and impacts, as well as remaining policy needs. Landowners' willingness to cooperate on forest management objectives across shared boundaries should be incentivized to address landscape-scale goals through landowner cooperatives or agglomeration bonuses with program participation (Aguilar et al., 2017; Delacote et al., 2016; Law & McSweeney, 2013; Pokorny & de Jong, 2015; Vokoun et al., 2010). Forestry reforms with poverty reduction goals should support the provision of multiple ecosystem services that family forests can provide to owners and their communities, beyond just timber products and cash crops (de Jong et al., 2016; Shi et al., 2016). Indeed, institutions and policies need to aim for the coordinated and simultaneous goals of poverty reduction and forest conservation, as each is tightly connected and cannot be achieved in isolation (Sandewall et al., 2015; Völker & Waibel, 2010). Some successful dual-goal policies that can be broadly applied include: incentivizing plantation establishment on marginal and unproductive agricultural areas; incentivizing the use of agroforestry practices to diversify products and boost productivity of trees and woodlots; developing timber and NTFP certification schemes, along with multi-household and multi-community product cooperatives to stabilize supply and enforce sustainable management objectives; clarifying and strengthening land tenure and access; developing markets for diverse forest products (and encourage agroforestry practices for "livelihood diversification"; Palacios et al., 2013; Sreeja et al., 2015); and enhancing the ability of institutions to enforce forest management regulations and support development and conservation policies (Ndayambaje, Heijman, & Mohren, 2013; Sandewall et al., 2015; Wilsey & Hildebrand, 2011). In many countries, governance and policy have yet to catch up to the on-the-ground realities, particularly when it comes to natural resource conservation and sustainable use (Sreeja et al., 2015).

Future literature reviews on family forest owners and landscape-scale dynamics need to be more holistic and inclusive in language and publication outlets. A significant quantity of research products excluded

from this review were published in French- and Spanish-only journals with no English titles or abstracts, and there is likely an equal amount of information in regional journals that are not well-indexed (although Google Scholar helped supplement Web of Science for non-indexed journals and for government reports). Also, my use of NVivo to aggregate the papers required the exclusion of scanned-image papers, losing older studies that would allow for an examination of trends over time. Thus, the major themes and relationships revealed in this review should be viewed conservatively. Important topics that were represented among the papers but not highlighted by NVivo nodes include wood mobilization on family forests, land restitution driving parcelization of forests in central and eastern Europe, and the influence of gender roles and labor migration on forest management decisions. Multiple large-scale trends, such as globalization of the workforce, widespread use of a small number of exotic species for timber plantations, and climate change are expected to have increasing impacts on forested landscapes, providing ample reason for subsequent reviews on these topics. Finally, future reviews will capture many of the very recent but relevant papers that I was unable to include (e.g., Burivalova et al., 2018; Eriksson, 2018; Laakkonen et al., 2018), including those published in this special issue of *Landscape & Urban Planning*.

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Appendix

Nodes identified either as most frequent words or added post hoc (indicated with *), and the words and phrases coded in each node. "Papers" is number of papers each node appeared in, and "References" is the total number of times (either as a word, phrase, or sentence) each node was coded among all 456 papers.

Node Name	Words and phrases coded	Papers	References
agriculture	agriculture, agrarian, farm, husbandry, USDA	451	18,455
agroforestry	agroforestry	191	2805
analysis	analysis	445	4543
area	area, expanse, region, field, expansive	455	25,692
biodiversity	biodiversity, biological diversity, species diversity, extinction	359	4345
biomass	biomass	175	2568
carbon	carbon, climate change	227	3553
community	community, communal, commune, ejidos	451	11,210
data	data, information	449	9505
deforestation	deforestation, forest loss	260	3937
ecological	ecology, ecological	417	6619
ecosystem	ecosystem, ecosystem services	391	4911
*energy	energy, bioenergy, biomass energy, cellulosic ethanol, charcoal, fuelwood	335	4175
environment	environmental, environmentalism, ecological values	431	4878
*exotic or invasive	alien, exotic, introduced species, invasive	216	2997
farmers	farmers, agrarian owners	321	6500
forest	forest, woodland, woods	454	64,263
forestry	forestry, production, timber, even- or odd-aged stands, forestry professionals, foresters	388	5178
habitat	habitat	295	2909
harvest	harvest, crop, glean, reap, cropping	434	11,901
household	household, family, homeowner	406	12,919
income	income, economy, economic, cash, money, wealth, poor, rich, socioeconomic	382	4776
land	land, holdings, estate, country	455	58,530
*land use	land use, land-use	433	5127
landowners	landowners, land owners, landholdings	283	6485
landscape	landscape, landscaping	433	10,871
methods	methods, methodology	428	2310
owners	owner, proprietor, manager	292	8713
ownership	ownership, possession, tenure, usufruct rights, *de jure*, *de facto*	304	4840
plantations	plantations, grove, orchard	282	4566
policy	policy, policies, program(s), incentives, taxes, subsidies, REDD+	410	7114
resources	resources, water, soil	440	6150
rural	rural, rustic	375	3732
scenario	scenario	199	2313
science	science, research	423	2658
size	size, acre, hectare, extent	384	3940
smallholder	smallholder	228	3750
social	social, culture, socialization, society, social network, communication, collaboration, cooperation	388	4477
spatial	spatial, pattern, adjacent, proximate, nearby	329	3231
species	species	361	9815
strategies	strategies, schemes	389	3439
study	study, examine, subject, work, analyze, report	454	28,132
support	support, abide, assist, back, champion, defend, encourage, endure, friend, help, livelihood, keep, etc.	454	15,753
*sustainable	sustainable, sustainable development, sustainability, Sustainable Development Goals	445	6551
tree	tree	411	12,214
tropical	tropical, tropics	273	3392
use	use, enjoyment, function, exploit, practice, purpose, role	454	37,605

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2018.10.017.

References

Acheampong, E., Insaidoo, T. F. G., & Ros-Tonen, M. A. F. (2016). Management of Ghana's modified taungya system: Challenges and strategies for improvement. *Agroforestry Systems, 90*(4), 659–674. https://doi.org/10.1007/s10457-016-9946-7.

Aguilar, T. X., Cai, Z., & Butler, B. (2017). Proximal association of land management preferences: Evidence from family forest owners. *PLoS One, 12*(1), e0169667. https://doi.org/10.1371/journal.pone.0169667.

Allen, K., Corre, M. D., Kurniawan, S., Rahayu Utami, S., & Veldkamp, E. (2016). Spatial variability surpasses land-use change effects on soil biochemical properties of converted lowland landscapes in Sumatra, Indonesia. *Geoderma, 284*, 42–50. https://doi.org/10.1016/j.geoderma.2016.08.010.

Angelsen, A., & Wunder, S. (2003). *Exploring the forest-poverty link: Key concepts, issues, and research implications.* Jakarta, Indonesia: CIFOR Occasional Paper No. 40.

Araujo, C., Bonjean, C. A., Combes, J.-L., Motel, P. C., & Reis, E. J. (2009). Property rights and deforestation in the Brazilian Amazon. *Ecological Economics, 68*(8–9), 2461–2468. https://doi.org/10.1016/j.ecolecon.2008.12.015.

Armesto, J. J., Smith-Ramirez, C., & Rozzi, R. (2001). Conservation strategies for biodiversity and indigenous people in Chilean forest ecosystems. *Journal of the Royal Society of New Zealand, 31*(4), 865–877. https://doi.org/10.1080/03014223.2001.9517681.

Asante, W. A., Acheampong, E., Kyereh, E., & Kyereh, B. (2017). Farmers' perspectives on climate change manifestations in smallholder cocoa farms and shifts in cropping systems in the forest-savannah transitional zone of Ghana. *Land Use Policy, 66*, 374–381. https://doi.org/10.1016/j.landusepol.2017.05.010.

Asare, R. A., Kyei, A., & Mason, J. J. (2013). The community resource management area mechanism: A strategy to manage African forest resources for REDD+. *Philosophical Transactions of the Royal Society B, 368*, 20120311. https://doi.org/10.1098/rstb.2012.0311.

Azhar, B., Saadun, N., Prideaux, M., & Lindenmayer, D. B. (2017). The global palm oil sector must change to save biodiversity and improve food security in the tropics. *Journal of Environmental Management, 203*, 457–466. https://doi.org/10.1016/j.jenvman.2017.08.021.

Baldwin, R. F., Tombulak, S. C., & Baldwin, E. D. (2009). Assessing risk of large-scale habitat conversion in lightly settled landscapes. *Landscape and Urban Planning, 91*(4), 219–225. https://doi.org/10.1016/j.landurbplan.2009.01.004.

Barbieri, A. F., & Carr, D. L. (2005). Gender-specific out-migration, deforestation and urbanization in the Ecuadorian Amazon. *Global and Planetary Change, 47*(2–4), 99–110. https://doi.org/10.1016/j.gloplacha.2004.10.005.

Barsimantov, J. A. (2010). Vicious and virtuous cycles and the role of external non government actors in community forestry in Oaxaca and Michoacan, Mexico. *Human Ecology, 38*(1), 49–63. https://doi.org/10.1007/s10745-009-9289-3.

Bawa, K. S., & Seidler, R. (2015). Deforestation and sustainable mixed-use landscapes: A view from the eastern Himalaya. *Annals of the Missouri Botanical Garden, 100*, 141–149. https://doi.org/10.3417/2012019.

BenDor, T., Shoemaker, D. A., Thill, J. C., & Dorning, M. A. (2014). A mixed-methods analysis of social-ecological feedbacks between urbanization and forest persistence. *Ecology and Society, 19*(3), 3. https://doi.org/10.5751/ES-06508-190303.

Bjärstig, T., & Kvastegård, E. (2016). Forest social values in a Swedish rural context: The private forest owners' perspective. *Forest Policy and Economics, 65*, 17–24. https://doi.org/10.1016/j.forpol.2016.01.007.

Blennow, K., Persson, E., Lindner, M., Faias, S. P., & Hanewinkel, M. (2014). Forest owner motivations and attitudes towards supplying biomass for energy in Europe. *Biomass & Bioenergy, 67*, 223–230. https://doi.org/10.1016/j.biombioe.2014.05.002.

Bliss, J. C. (2003). Sustaining family forests in rural landscapes: Rationale, challenges, and an illustration from Oregon, USA. *Small-scale Forest Economics, Management and Policy, 2*(1), 1–8. https://doi.org/10.1007/s11842-003-001-y.

Boffa, J. C., Kindt, R., Katumba, B., Jourget, J. G., & Turyomurugyendo, L. (2008). Management of tree diversity in agricultural landscapes around Mabira Forest Reserve, Uganda. *African Journal of Ecology, 46*, 24–32. https://doi.org/10.1111/j.1365-2028.2008.00926.x.

Boutthavong, S., Hyakumura, K., Ehara, M., & Fujiwara, T. (2016). Historical changes of land tenure and land use rights in a local community: A case study in Lao PDR. *Land, 5*(2), 11. https://doi.org/10.3390/land5020011.

Brunner, A., Currie, W. S., & Miller, S. (2015). Cellulosic ethanol production: Landscape scale net carbon strongly affected by forest decision making. *Biomass & Bioenergy, 83*, 32–41. https://doi.org/10.1016/j.biombioe.2015.08.002.

Bullock, R., Mithöfer, D., & Vihemäki, H. (2014). Sustainable agricultural intensification: the role of cardamom agroforestry in the East Usambaras, Tanzania. *International Journal of Agricultural Sustainability, 12*(2), 109–129. https://doi.org/10.1080/14735903.2013.840436.

Bürgi, M., Steck, C., & Bertiller, R. (2010). Evaluating a forest conservation plan with historical vegetation data: A transdisciplinary case study from the Swiss lowlands. *Gaia – Ecological Perspectives for Science and Society, 19*(3), 204–212. https://doi.org/10.14512/gaia.19.3.10.

Burivalova, A., Towsey, M., Boucher, T., Truskinger, A., Apelis, C., Roe, P., & Game, E. T. (2018). Using soundscapes to detect variable degrees of human influence on tropical forests in Papua New Guinea. *Conservation Biology, 332*(1), 205–215. https://doi.org/10.1111/cobi.12968.

Butler, B. J., Hewes, J. H., Dickinson, B. J., Adrejczyk, K., Butler, S. M., & Markowski-Lindsay, M. (2016). Family forest ownerships of the United States, 2013: Findings from the USDA Forest Service's National Woodland Owner Survey. *Journal of Forestry, 114*(6), 638–647. https://doi.org/10.5849/jof.15-099.

Butler, B. J., & Leatherberry, E. C. (2004). America's family forests. *Journal of Forestry, 102*(7), 4–14.

Cai, Z., Narine, L. L., D'Amato, A., & Aguilar, F. X. (2016). Attitudinal and revenue effects on non-industrial private forest owners' willingness-to-harvest timber and woody biomass. *Forest Policy and Economics, 63*, 52–61. https://doi.org/10.1016/j.forpol.2015.11.007.

Carlson, M. J., Mitchell, R., & Rodriguez, L. (2011). Scenario analysis to identify viable conservation strategies in Paraguay's imperiled Atlantic forest. *Ecology and Society, 16*(3), 8. https://doi.org/10.5751/ES-04267-160308.

Carlsson, M., Andersson, M., Dahlin, B., & Sallnäs, O. (1998). Spatial patterns of habitat protection in areas with non-industrial private forestry – hypotheses and implications. *Forest Ecology and Management, 107*, 203–211. https://doi.org/10.1016/S0378-1127(97)00337-X.

Chen, B. X., & Nakama, Y. (2015). Residents' preference and willingness to conserve homestead woodlands: Coastal villages in Okinawa Prefecture, Japan. *Urban Forestry and Urban Greening, 14*(4), 919–931. https://doi.org/10.1016/j.ufug.2015.08.008.

Colby, K. T. (1988). Public access to private land – Allemansrätt in Sweden. *Landscape and Urban Planning, 15*, 253–264.

Coomes, O. T., Takasaki, Y., & Rhemtulla, J. M. (2016). Forests as landscapes of social inequality: Tropical forest cover and land distribution among shifting cultivators. *Ecology and Society, 21*(3), 20. https://doi.org/10.5751/ES-08684.

Cotta, J. N. (2015). Contributions of local floodplain resources to livelihoods and household income in the Peruvian Amazon. *Forest Policy and Economics, 59*, 35–46. https://doi.org/10.1016/j.forpol.2015.05.008.

Creutzburg, M. K., Scheller, R. M., Lucash, M. S., & Evers, L. B. (2016). Bioenergy harvest, climate change, and forest carbon in the Oregon Coast Range. *Global Change Biology Bioenergy, 8*(2), 357–370. https://doi.org/10.1111/gcbb.12255.

Dawson, I. K., Guariguata, M. R., Loo, J., Weber, J. C., Lengkeek, A., Bush, D., ... Jamnadass, R. (2013). What is the relevance of smallholders' agroforestry systems for conserving tropical tree species and genetic diversity in circa situm, in situ and ex situ settings? A reveiw. *Biodiversity Conservation, 22*, 301–324. https://doi.org/10.1007/s10531-012-0429-5.

Dawson, I. K., Leakey, R., Clement, C. R., Weber, J. C., Cornelius, J. P., Roshetko, J. M., ... Jamnadass, R. (2014). The management of tree genetic resources and the livelihoods of rural communities in the tropics: Non-timber forest products, smallholder agroforestry practices and tree commodity crops. *Forest Ecology and Management, 333*, 9–21. https://doi.org/10.1016/j.foreco.2014.01.021.

Dawson, I. K., Vinceti, B., Weber, J. C., Neufeldt, H., Russell, J., Lengkeek, A. G., ... Jamnadass, R. (2011). Climate change and tree genetic resource management: Maintaining and enhancing the productivity and value of smallholder tropical agroforestry landscapes. A review. *Agroforestry Systems, 81*, 67–78. https://doi.org/10.1007/s10457-010-9302-2.

de Jong, W., Galloway, G., Katila, P., & Pacheco, P. (2016). Incentives and constraints of community and smallholder forestry. *Forests, 7*, 209. https://doi.org/10.3390/f7090209.

Deconchat, M., Gibon, A., Cabanettes, A., du Bus de Warnaffe, G., Hewison, M., Garine, E., ... Balent, G. (2007). How to set up a research framework to analyze social-ecological interactive processes in a rural landscape. *Ecology and Society, 12*(1), 15. https://doi.org/10.5751/ES-01990-120115.

Delacote, P., Robinson, E. J. A., & Roussel, S. (2016). Deforestation, leakage and avoided deforestation policies: A spatial analysis. *Resource and Energy Economics, 45*, 192–210. https://doi.org/10.1016/j.reseneeco.2016.06.006.

Dermawan, A., Kemp-Benedict, E., Huber-Lee, A., & Fencl, A. (2013). Testing a multi-scale scenario approach for smallholder tree plantations in Indonesia and Vietnam. *Technological Forecasting and Social Change, 80*(4), 762–771. https://doi.org/10.1016/j.techfore.2012.10.021.

Dhubháin, Á. N., Maguire, K., & Farrelly, N. (2010). The harvesting behavior of Irish private forest owners. *Forest Policy and Economics, 12*(7), 513–517. https://doi.org/10.1016/j.forpol.2010.05.008.

Di Giminiani, P. (2016). How to manage a forest: Environmental governance in neoliberal Chile. *Anthropological Quarterly, 89*(3), 723–752. https://doi.org/10.1353/anq.2016.0045.

DiGiano, M., Ellis, E., & Keys, E. (2013). Changing landscapes for forest commons: Linking land tenure with forest cover change following Mexico's 1992 agrarian counter-reforms. *Human Ecology, 41*(5), 707–723. https://doi.org/10.1007/s10745-013-9581-0.

Donnelly, S. (2011). Land-use portfolios and the management of private landholdings in south-central Indiana. *Regional Environmental Change, 11*(1), 97–109. https://doi.org/10.1007/s10113-010-0124-6.

Dorning, M. A., Smith, J. W., Shoemaker, D. A., & Meentemeyer, R. K. (2015). Changing decisions in a changing landscape: How might forest owners in an urbanizing region respond to emerging bioenergy markets? *Land Use Policy, 49*, 1–10. https://doi.org/10.1016/j.landusepol.2015.06.020.

Duesberg, S., Dhubháin, Á. N., & O'Connor, D. (2014). Assessing policy tools for encouraging farm afforestation in Ireland. *Land Use Policy, 38*, 194–203. https://doi.org/10.1016/j.landusepol.2013.11.001.

Duesberg, S., O'Connor, D., & Dhubháin, Á. N. (2013). To plant or not to plant - Irish farmers' goals and values with regard to afforestation. *Land Use Policy, 32*, 155–164. https://doi.org/10.1016/j.landusepol.2012.10.021.

Ellis, E. A., Romero Montero, J. A., Hernández Gómez, I. U., Porter-Bolland, L., & Ellis, P. W. (2017). Private property and Mennonites are major drivers of forest cover loss in central Yucatan Peninsula, Mexico. *Land Use Policy, 69*, 474–484.

Eloy, L., Méral, P., Ludewigs, T., Pinheiro, G. T., & Singer, B. (2012). Payments for ecosystem services in Amazonia. The challenge of land use heterogeneity in agricultural frontiers near Cruzeiro do Sul (Acre, Brazil). *Journal of Environmental Planning and Management, 55*(6), 685–703. https://doi.org/10.1080/09640568.2011.621021.

Eriksson, L. (2018). Effects of policy measures and moderating factors on climate change adaptation among private forest owners in Sweden. *Society & Natural Resources, 31*(4), 409–423. https://doi.org/10.1080/08941920.2017.1382629.

Field, C. R., Dayer, A. A., & Elphick, C. S. (2017). Landowner behavior can determine the success of conservation strategies for ecosystem migration under sea-level rise. *Proceedings of the National Academy of Science USA, 114*(34), 9134–9139. https://doi.org/10.1073/pnas.1620319114.

Fischer, A. P., & Bliss, J. C. (2008). Behavioral assumptions of conservation policy: Conserving oak habitat on family-forest land in the Willamette Valley, Oregon. *Conservation Biology, 22*(2), 275–283. https://doi.org/10.1111/j.1523-1739.2007.00873.x.

Fischer, A. P., & Bliss, J. C. (2009). Framing conservation on private lands: Conserving oak in Oregon's Willamette Valley. *Society and Natural Resources, 22*(10), 884–900. https://doi.org/10.1080/08941920802314926.

Fischer, A. P., & Charlney, S. (2012). Private forest owners and invasive plants: Risk perception and management. *Invasive Plant Science and Management, 5*(3), 375–389. https://doi.org/10.1614/IPSM-D-12-00005.1.

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... Snyder, P. K. (2005). Global consequences of land use. *Science, 309*(5734), 570–574. https://doi.org/10.1126/science.1111772.

Fries, C., Carlsson, M., Dahlin, B., Lämås, T., & Sallnäs, O. (1998). A review of conceptual landscape planning models for multiobjective forestry in Sweden. *Canadian Journal of Forest Research, 28*(2), 159–167. https://doi.org/10.1139/x97-204.

Friis, C., Nielsen, J. O., Otero, I., Haberl, H., Niewöhner, J., & Hostert, P. (2016). From teleconnection to telecoupling: Taking stock of an emerging framework in land system science. *Journal of Land Use Science, 11*(2), 131–153. https://doi.org/10.1080/1747423X.2015.1096423.

Fu, Y., Chen, J., Guo, H., Chen, A., Cui, J., & Hu, H. (2009). The role of non-timber forest products during agroecosystem shift in Xishuangbanna, southwestern China. *Forest Policy and Economics, 11*(1), 18–25. https://doi.org/10.1016/j.forpol.2008.08.003.

Garedew, E., Sandewall, M., & Soderberg, U. (2012). A dynamic simulation model of land-use, population, and rural livelihoods in the Central Rift Valley of Ethiopia. *Environmental Management, 49*(1), 151–162. https://doi.org/10.1007/s00267-011-9783-4.

Gass, R., Rickenbach, M., Schulte, L., & Zeuli, K. (2009). Cross-boundary coordination on forested landscapes: Investigating alternatives for implementation. *Environmental Management, 43*(1), 107–117. https://doi.org/10.1007/s00267-008-9195-2.

Germain, R. H., Brazill, K., & Stehman, S. V. (2006). Forestland parcelization in upstate New York despite economic stagnation and a declining population. *Northern Journal of Applied Forests, 23*(4), 280–287. https://doi.org/10.1093/njaf/23.4.280.

Godar, J., Tizado, E. J., & Pokorny, B. (2012). Who is responsible for deforestation in the Amazon? A spatially explicit analysis along the Transamazon Highway in Brazil. *Forest Ecology and Management, 267*, 58–73. https://doi.org/10.1016/j.foreco.2011.11.046.

Goh, C. S., Juninger, M., Cocchi, M., Marchal, D., Thrän, D., Hennig, C., ... Deutmeyer, M. (2013). Wood pellet market and trade: A global perspective. *Biofuels, Bioproducts & Biorefining, 7*(1), 24–42. https://doi.org/10.1002/bbb.1366.

Górriz-Mifsud, E., Varela, E., Piqué, M., & Prokofieva, I. (2016). Demand and supply of ecosystem services in a Mediterranean forest: Computing payment boundaries. *Ecosystem Services, 17*, 53–63. https://doi.org/10.1016/j.ecoser.2015.11.006.

Gregory, S. A., Conway, M. C., & Sullivan, J. (2003). Econometric analyses of non-industrial forest landowners: Is there anything left to study? *Journal of Forest Economics, 9*(2), 137–164. https://doi.org/10.1078/1104-6899-00028.

Grossman, J. J. (2015). Eucalypts in agroforestry, reforestation, and smallholders' conceptions of "Nativeness": A multiple case study of plantation owners in Eastern Paraguay. *Small-scale Forestry, 14*, 39–59. https://doi.org/10.1007/s11842-014-9272-8.

Haile, G., Lemenih, M., Senbeta, F., & Itanna, F. (2017). Plant diversity and determinant factors across smallholder agricultural management units in Central Ethiopia. *Agroforestry Systems, 91*, 677–695. https://doi.org/10.1007/s10457-016-0038-5.

Haines, A. L., Kennedy, T. T., & McFarlane, D. L. (2011). Parcelization: Forest change agent in northern Wisconsin. *Journal of Forestry, 109*(2), 101–108. https://doi.org/10.1093/jof/109.2.101.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., ... Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science, 342*(6160), 850–853. https://doi.org/10.1126/science.1244693.

Hartter, J., Lucas, C., Gaughan, A. E., & Aranda, L. L. (2008). Detecting tropical dry forest succession in a shifting cultivation mosaic of the Yucatán Peninsula, Mexico. *Applied Geography, 28*, 134–149. https://doi.org/10.1016/j.apgeog.2007.07.013.

Hawes, P., & Memon, P. A. (1998). Prospects for sustainable management of indigenous forests on private land in New Zealand. *Journal of Environmental Management, 52*(2), 113–130. https://doi.org/10.1006/jema.1997.0164.

Henders, S., & Ostwald, M. (2014). Accounting methods for international land-related leakage and distant deforestation drivers. *Ecological Economics, 99*, 21–28. https://doi.org/10.1016/j.ecolecon.2014.01.005.

Hengeveld, G. M., Schull, E., Tubins, R., & Sallnas, O. (2017). Forest landscape development scenarios (FoLDS) – A framework for integrating forest models, owners' behavior and socio-economic developments. *Forest Policy and Economics, 85*, 245–255. https://doi.org/10.1016/j.forpol.2017.03.007.

Hodgdon, B., & Tyrrell, M. (2003). *Literature review: An annotated bibliography on family forest owners.* GISF research paper.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., & Romijn, T. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters, 7*, 044009. https://doi.org/10.1088/1748-9326/7/4/044009.

Hostettler, S. (2007). *Land use changes and transnational migration: The impact of remittances in western Mexico*Ph.D. thesis. École Polytechnique Fédéral de Lausanne.

Houghton, R. A., House, J. I., Pongratz, J., van der Werf, G. R., DeFries, R. S., Hansen, M. C., ... Ramankutty, N. (2012). Carbon emissions from land use and land-cover change. *Biogeosciences, 9*(12), 5125–5142. https://doi.org/10.5194/bg-9-5125-2012.

Hull, R. B., Robertson, D. P., & Buhyoff, G. J. (2004). "Boutique" forestry – New forest practices in urbanizing landscapes. *Journal of Forestry, 102*(1), 14–19. https://doi.org/10.1093/jof/102.1.14.

Kabir, M. E., & Webb, E. L. (2008). Can homegardens conserve biodiversity in Bangladesh? *Biotropica, 40*(1), 95–103. https://doi.org/10.1111/j.1744-7429.2007.00346.x.

Kaetzel, B. R., Majumdar, I., Teeter, L. D., & Butler, B. J. (2012). Regional differences among family forest landowners using National Woodland Owner Survey results. *Southern Journal of Applied Forestry, 36*(3), 141–145. https://doi.org/10.5849/sjaf.11-007.

Khanal, P. N., Grebner, D. L., Munn, I. A., Grado, S. C., Grala, R. K., & Henderson, J. E. (2017). Typology of nonindustrial private forest landowners and forestry behavior: Implications for forest carbon sequestration in the Southern US. *Small-scale Forestry, 16*, 419–434. https://doi.org/10.1007/s11842-017-9363-4.

Kilgore, M. A., Snyder, S. A., Block-Torgerson, K., & Taff, S. J. (2013). Challenges in characterizing a parcelized forest landscape: Why metric, scale, threshold, and definitions matter. *Landscape and Urban Planning, 110*, 36–47. https://doi.org/10.1016/j.landurbplan.2012.09.009.

Kittredge, D. B. (2004). Extension/Outreach implications for America's family forest owners. *Journal of Forestry, 15–18*(Oct/Nov), https://doi.org/10.1093/jof/102.7.15.

Kittredge, D. B., Finley, A. O., & Foster, D. R. (2003). Timber harvesting as ongoing disturbance in a landscape of diverse ownership. *Forest Ecology and Management, 180*, 425–442. https://doi.org/10.1016/S0378-1127(02)00561-3.

Kline, J. D., Azuma, D. L., & Alig, R. J. (2004). Population growth, urban expansion, and private forestry in western Oregon. *Forest Science, 50*(1), 33–43. https://doi.org/10.1093/forestscience/50.1.33.

Kline, J. D., Moses, A., Lettman, G. J., & Azuma, D. L. (2007). Modeling forest and range land development in rural locations, with examples from eastern Oregon. *Landscape and Urban Planning, 80*(3), 320–332. https://doi.org/10.1016/j.landurbplan.2006.10.017.

Knoot, T. G., & Rickenbach, M. (2014). Forester networks: The intersection of private lands policy and collaborative capacity. *Land Use Policy, 38*, 388–396. https://doi.org/10.1016/j.landusepol.2013.11.025.

Ko, D. W., & He, H. S. (2011). Characterizing the historical process of private forestland ownership parcelization and aggregation in the Missouri Ozarks, USA, from 1930 to 2000. *Landscape and Urban Planning, 102*, 262–270. https://doi.org/10.1016/j.landurbplan.2011.05.004.

Ko, D. W., He, H. S., & Larsen, D. R. (2006). Simulating private land ownership fragmentation in the Missouri Ozarks, USA. *Landscape Ecology, 21*, 671–686. https://doi.org/10.1007/s10980-005-5242-z.

Kurttila, M., & Pukkala, T. (2003). Combining holding-level economic goals with spatial landscape-level goals in the planning of multiple ownership forestry. *Landscape Ecology, 18*(5), 529–541. https://doi.org/10.1023/A:1026054227874.

Kuyah, S., Dietz, J., Muthuri, C., van Noordwijk, M., & Neufeldt, H. (2013). Allometry and partitioning of above- and below-ground biomass in farmed eucalyptus species dominant in Western Kenyan agricultural landscapes. *Biomass and Bioenergy, 55*, 276–284. https://doi.org/10.1016/j.biombioe.2013.02.011.

Kuyah, S., & Rosenstock, T. S. (2015). Optimal measurement strategies for aboveground tree biomass in agricultural landscapes. *Agroforestry Systems, 89*, 125–133. https://doi.org/10.1007/s10457-014-9747-9.

L'Roe, A. W., & Allred, S. B. (2013). Thriving or surviving? Forester responses to private forestland parcelization in New York State. *Small-Scale Forestry, 12*(3), 353–376. https://doi.org/10.1007/s11842-012-9216-0.

Laakkonen, A., Zimmerer, R., Kähkönen, T., Hujala, T., Takala, T., & Tikkanen, J. (2018). Forest owners' attitudes toward pro-climate and climate-responsive forest management. *Forest Policy & Economics, 87*, 1–10. https://doi.org/10.1016/j.forpol.2017.11.001.

Laird, S. A., Awung, G. L., Lysinge, R. J., & Ndive, L. E. (2011). The interweave of people and place: Biocultural diversity in migrant and indigenous livelihoods around Mount Cameroon. *International Forestry Review, 13*(3), 275–293.

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., ... Xu, J. C. (2001). The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change – Human and Policy Dimensions, 11*(4), 261–269. https://doi.org/10.1016/S0959-3780(01)00007-3.

Lasco, R. D., Delfino, R. J. P., & Espaldon, M. L. O. (2014). Agroforestry systems: Helping smallholders adapt to climate risks while mitigating climate change. *WIREs Climate Change, 5*, 825–833. https://doi.org/10.1002/wcc.301.

Latta, G. S., Adams, D. M., Bell, K. P., & Kline, J. D. (2016). Evaluating land-use and private forest management responses to a potential forest carbon offset sales program in western Oregon (USA). *Forest Policy and Economics, 65*, 1–8. https://doi.org/10.1016/j.forpol.2016.01.004.

Law, E. A., Bryan, B. A., Meijaard, E., Mallawaarachchi, T., Struebig, M., Watts, M. E., & Wilson, K. A. (2017). Mixed policies give more options in multifunctional tropical forest landscapes. *Journal of Applied Ecology, 54*(1), 51–60. https://doi.org/10.1111/1365-2664.12666.

Law, J., & McSweeney, K. (2013). Looking under the canopy: Rural smallholders and forest recovery in Appalachian Ohio. *Geoforum, 44*, 182–192. https://doi.org/10.1016/j.geoforum.2012.09.008.

Lee, J. S. H., Garcia-Ulloa, J., Ghazoul, J., Obidzinski, K., & Koh, L. P. (2014). Modelling environmental and socio-economic trade-offs associated with land-sparing and land-sharing approaches to oil palm expansion. *Journal of Applied Ecology, 51*, 1366–1377.

https://doi.org/10.1111/1365-2664.12286.
Lee, J., Ingalls, M., Erickson, J. D., & Wollenberg, E. (2016). Bridging organizations in agricultural carbon markets and poverty alleviation: An analysis of pro-Poor carbon market projects in East Africa. *Global Environmental Change, 39*, 98–107. https://doi.org/10.1016/j.gloenvcha.2016.04.015.
Lidskog, R., & Löfmarck, E. (2016). Fostering a flexible forest: Challenges and strategies in the advisory practice of a deregulated forest management system. *Forest Policy and Economics, 62*, 177–183. https://doi.org/10.1016/j.forpol.2015.10.015.
Lindbladh, M., Felton, A., Trubins, R., & Sallnäs, O. (2011). A landscape and policy perspective on forest conversion: Long-tailed tit (*Aegithalos caudatus*) and the allocation of deciduous forests in southern Sweden. *European Journal of Forest Research, 130*, 861–869. https://doi.org/10.1007/s10342-010-0478-9.
Lind-Riehl, J., Jeltema, S., Morrison, M., Shirkey, G., Mayer, A. L., Rouleau, M. D., & Winkler, R. (2015). Family legacies and community networks shape private forest management in the western Upper Peninsula of Michigan (USA). *Land Use Policy, 45*, 95–102. https://doi.org/10.1016/j.landusepol.2015.01.005.
Llewellyn, D. W., Shaffer, G. P., Craig, N. J., Creasman, L., Pashley, D., Swan, M., & Brown, C. (1996). A decision-support system for prioritizing restoration sites on the Mississippi River Alluvial Plain. *Conservation Biology, 10*(5), 1446–1455. https://doi.org/10.1046/j.1523-1739.1996.10051446.x.
Lobovikov, M., Schoene, D., & Lou, Y. (2012). Bamboo in climate change and rural livelihoods. *Mitigation and Adaptation Strategies for Global Change, 17*(3), 261–276. https://doi.org/10.1007/s11027-011-9324-8.
Lopez, S. L. (2015). *The remittance landscape: Spaces of migration in Rural Mexico and Urban USA* (pp. 336). Cambridge University Press.
Ma, Z., & Kittredge, D. B. (2011). How family forest owners consider timber harvesting, land sale, and conservation easement decisions: Insights from Massachusetts, USA. *International Journal of Forestry Research, 2011*, 290353. https://doi.org/10.1155/2011/290353.
Markowski-Lindsay, M., Stevens, T., Kittredge, D. B., Butler, B. J., Catanzaro, P., & Damery, D. (2012). Family forest owner preferences for biomass harvesting in Massachusetts. *Forest Policy and Economics, 14*(1), 127–135. https://doi.org/10.1016/j.forpol.2011.08.001.
Matilainen, A., & Lähdesmäki, M. (2014). Nature-based tourism in private forests: Stakeholder management balancing the interests of entrepreneurs and forest owners? *Journal of Rural Studies, 35*, 70–79. https://doi.org/10.1016/j.jrurstud.2014.04.007.
Matta, J. R., Alavalapati, J., & Tanner, G. (2007). A framework for developing market-based policies to further biodiversity on non-industrial private forests (NIPF). *Forest Policy and Economics, 9*, 779–788. https://doi.org/10.1016/j.forpol.2006.03.008.
Mayer, A. L., Buma, B., Davis, A., Gagné, S. A., Loudermilk, E. L., Scheller, R., ... Franklin, J. (2016). How landscape ecology informs global land-change science and policy. *BioScience, 66*(6), 458–469. https://doi.org/10.1093/biosci/biw035.
Mayer, A. L., Kauppi, P. E., Angelstam, P. K., Zhang, Y., & Tikka, P. M. (2005). Importing timber, exporting ecological impact. *Science, 308*(5720), 359–360. https://doi.org/10.1126/science.1109476.
Mayer, A. L., & Rouleau, M. D. (2013). ForestSim model of impacts of smallholder dynamics: Forested landscapes of the Upper Peninsula of Michigan. *International Journal of Forestry Research, 2013*, 520207. https://doi.org/10.1155/2013/520207.
Mbow, C., Smith, P., Skole, D., Duguma, L., & Bustamante, M. (2014). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability, 6*, 8–14. https://doi.org/10.1016/j.cosust.2013.09.002.
McCracken, S. D., Brondizio, E. S., Nelson, D., Moran, E. F., Siqueira, A. D., & Rodriguez-Pedraza, C. (1999). Remote sensing and GIS at farm property level: Demography and deforestation in the Brazilian Amazon. *Photogrammetric Engineering and Remote Sensing, 65*(11), 1311–1320.
McDonald, R. I., Motzkin, G., Bank, M. S., Kittredge, D. B., Burk, J., & Foster, D. R. (2006). Forest harvesting and land-use conversion over two decades in Massachusetts. *Forest Ecology and Management, 227*, 31–41. https://doi.org/10.1016/j.foreco.2006.02.006.
McDonald, R. R. I., Motzkin, G., & Foster, D. R. (2008). The effect of logging on vegetation composition in Western Massachusetts. *Forest Ecology and Management, 255*, 4021–4031. https://doi.org/10.1016/j.foreco.2008.03.054.
Mertz, O., Müller, D., Sikor, T., Hett, C., Heinimann, A., Castella, J.-C., ... Sun, Z. (2012). The forgotten D: Challenges of addressing forest degradation in complex mosaic landscapes under REDD+. *Danish Journal of Geography, 112*(1), 63–76. https://doi.org/10.1080/00167223.2012.709678.
Meyfroidt, P., Rudel, T. K., & Lambin, E. F. (2010). Forest transitions, trade, and the global displacement of land use. *Proceedings of the National Academy of Sciences USA, 107*(49), 20917–20922. https://doi.org/10.1073/pnas.1014773107.
Millennium Ecosystem Assessment (2005). *Ecosystems and human well-being: Synthesis.* Washington, D. C.: Island Press.
Miller, D. C., Munoz-Mora, J. C., & Christiaensen, L. (2017). Prevalence, economic contribution, and determinants of trees on farms across Sub-Saharan Africa. *Forest Policy and Economics, 84*, 47–61. https://doi.org/10.1016/j.forpol.2016.12.005.
Milne, R. J., & Bennett, L. P. (2007). Biodiversity and ecological value of conservation lands in agricultural landscapes of southern Ontario, Canada. *Landscape Ecology, 22*(5), 657–670. https://doi.org/10.1007/s10980-006-9063-5.
Min-Venditti, A. A., Moore, G. W., & Fleischman, F. (2017). What policies improve forest cover? A systematic review of research from Mesoamerica. *Global Environmental Change, 47*(21–27), https://doi.org/10.1016/j.gloenvcha.2017.08.010.
Moreno-Calles, A. I., Casas, A., García-Frapolli, E., & Torres-García, I. (2012). Traditional agroforestry systems of multi-crop "milpa" and "chichipera" cactus forest in the arid Tehuacan Valley, Mexico: Their management and role in people's subsistence. *Agroforestry Systems, 84*(2), 207–226. https://doi.org/10.1007/s10457-011-9460-x.
Mozgeris, G., Brukas, V., Stanislovaitis, A., Kavaliauskas, M., & Palicinas, M. (2017). Owner mapping for forest scenario modelling – A Lithuanian case study. *Forest Policy and Economics, 85*(2), 235–244. https://doi.org/10.1016/j.forpol.2016.02.002.
Nair, P. K. R. (1998). Directions in tropical agroforestry research: Past, present, and future. *Agroforestry Systems, 38*(1–3), 223–245. https://doi.org/10.1023/A:1005943729654.
Nakakaawa, C., Aune, J., & Vedeld, P. (2010). Changes in carbon stocks and tree diversity in agro-ecosystems in south western Uganda: What role for carbon sequestration payments? *New Forests, 40*, 19–44. https://doi.org/10.1007/s11056-009-9180-5.
Nath, S., Nath, A. J., Sileshi, G. W., & Das, A. K. (2017). Biomass stocks and carbon storage in *Barringtonia acutangula* floodplain forests in North East India. *Biomass & Bioenergy, 98*, 37–42. https://doi.org/10.1016/j.biombioe.2017.01.014.
Ndayambaje, J. D., Heijman, W. J. M., & Mohren, G. M. J. (2013). Farm woodlots in rural Rwanda: Purposes and determinants. *Agroforestry Systems, 87*, 797–814. https://doi.org/10.1007/s10457-013-9597-x.
Newbold, T., Hudson, L. N., Hill, S. L. L., Contu, S., Lysenko, I., Senior, R. A., ... Purvis, A. (2015). Global effects of land use on local terrestrial biodiversity. *Nature, 520*, 45–50. https://doi.org/10.1038/nature14324.
Nordén, A., Coria, J., Jönsson, A. M., Lagergren, F., & Lehsten, V. (2015). Divergence in stakeholders' preferences: Evidence from a choice experiment on forest landscapes preferences in Sweden. *Ecological Economics, 132*, 179–195. https://doi.org/10.1016/j.ecolecon.2016.09.032.
Norfolk, O., Asale, A., Temesgen, T., Denu, D., Platts, P. J., Marchant, R., & Yewhalaw, D. (2017). Diversity and composition of tropical butterflies along an Afromontane agricultural gradient in the Jimma Highlands, Ethiopia. *Biotropica, 49*(3), 346–354. https://doi.org/10.1111/btp.12421.
Ochoa-Quintero, J. M., Gardner, T. A., Rosa, I., de Barros Ferraz, S. F., & Sutherland, W. J. (2015). Thresholds of species loss in Amazonian deforestation frontier landscapes. *Conservation Biology, 29*(2), 440–451. https://doi.org/10.1111/cobi.12446.
Odum, W. E. (1982). Environmental degradation and the tyranny of small decisions. *BioScience, 32*(9), 728–729. https://doi.org/10.2307/1308718.
Oestreicher, J. S., Farella, N., Paquet, S., Davidson, R., Lucotte, M., Mertens, F., & Saint-Charles, J. (2014). Livelihood activities and land-use at a riparian frontier of the Brazilian Amazon: Quantitative characterization and qualitative insights into the influence of knowledge, values, and beliefs. *Human Ecology, 42*(4), 521–540. https://doi.org/10.1007/s10745-014-9667-3.
Ohe, Y., Ikei, H., Song, C., & Miyazaki, Y. (2017). Evaluating the relaxation effects of emerging forest-therapy tourism: A multidisciplinary approach. *Tourism Management, 62*, 322–334. https://doi.org/10.1016/j.tourman.2017.04.010.
Oli, B. N., Treue, T., & Larsen, H. O. (2015). Socio-economic determinants of growing trees on farms in the middle hills of Nepal. *Agroforestry Systems, 89*(5), 765–777. https://doi.org/10.1007/s10457-015-9810-1.
Pacheco, P. (2012). Smallholders and communities in timber markets: Conditions shaping diverse forms of engagement in tropical Latin America. *Conservation and Society, 10*(2), 114–123. https://doi.org/10.4103/0972-4923.97484.
Palacios, M. R., Huber-Sannwald, E., Barrios, L. G., de Paz, F. P., Hernández, J. C., & de Mendoza, M. G. G. (2013). Landscape diversity in a rural territory: Emerging land use mosaics coupled to livelihood diversification. *Land Use Policy, 30*, 814–824. https://doi.org/10.1016/j.landusepol.2012.06.007.
Pan, Y. D., Birdsey, R. A., Fang, J. Y., Houghton, R., Kauppi, P. E., Kurz, W. A., ... Hayes, D. (2011). A large and persistent carbon sink in the world's forests. *Science, 333*(6045), 988–993. https://doi.org/10.1126/science.1201609.
Parry, L., Barlow, J., & Peres, C. A. (2009). Allocation of hunting effort by Amazonian smallholders: Implications for conserving wildlife in mixed-use landscapes. *Biological Conservation, 142*, 1777–1786. https://doi.org/10.1016/j.biocon.2009.03.018.
Pinard, F., Joetzjer, E., Kindt, R., & Kehlenbeck, K. (2014). Are coffee agroforestry systems suitable for circa situm conservation of indigenous trees? A case study from Central Kenya. *Biodiversity Conservation, 23*, 467–495. https://doi.org/10.1007/s10531-013-0615-0.
Plieninger, T., Bieling, C., Fagerholm, N., Byg, A., Hartel, T., Hurley, P., ... Huntsinger, L. (2015). The role of cultural ecosystem services in landscape management and planning. *Current Opinion in Environmental Sustainability, 14*, 28–33. https://doi.org/10.1016/j.cosust.2015.02.006.
Plieninger, T., Ferranto, S., Huntsinger, L., Kelly, M., & Getz, C. (2012). Appreciation, use, and management of biodiversity and ecosystem services in California's working landscapes. *Environmental Management, 50*(3), 427–440. https://doi.org/10.1007/s00267-012-9900-z.
Pokorny, B., & de Jong, W. (2015). Smallholders and forest landscape transitions: Locally devised development strategies of the tropical Americas. *International Forestry Review, 17*(S1), 1–19. https://doi.org/10.1505/146554815814668981.
Põllumäe, P., Korjus, H., & Paluots, T. (2014). Management motives of Estonian private forest owners. *Forest Policy and Economics, 42*, 8–14. https://doi.org/10.1016/j.forpol.2014.02.007.
Radel, C., Schmook, B., & McCandless, S. (2010). Environment, transnational labor migration, and gender: Case studies from southern Yucatán, Mexico and Vermont, USA. *Population and Environment, 32*, 177–197. https://doi.org/10.1007/s11111-010-0124-y.
Rahman, S. A., Sunderland, T., Roshetko, J. M., & Healey, J. R. (2017). Facilitating smallholder tree farming in fragmented tropical landscapes: Challenges and potentials for sustainable land management. *Journal of Environmental Management, 198*(110–121), https://doi.org/10.1016/j.jenvman.2017.04.047.
Rai, R. K., Scarborough, H., Subedi, N., & Lamichhane, B. (2012). Invasive plants – Do they devastate or diversify rural livelihoods? Rural farmers' perception of three invasive plants in Nepal. *Journal for Nature Conservation, 20*(3), 170–176. https://doi.org/10.1016/j.jnc.2012.01.003.
Redo, D. J., Grau, H. R., Aide, T. M., & Clark, M. L. (2012). Asymmetric forest transition driven by the interaction of socioeconomic development and environmental heterogeneity in Central America. *Proceedings of the National Academy of Science USA,*

109(23), 8839–8844. https://doi.org/10.1073/pnas.1201664109.

Rickenbach, M. G., Guries, R. P., & Schmoldt, D. L. (2006). Membership matters: Comparing members and non-members of NIPF owner organizations in southwest Wisconsin, USA. *Forest Policy and Economics, 8*(1), 93–103. https://doi.org/10.1016/j.forpol.2004.05.006.

Riedel, J., Dorn, S., Plath, M., Potvin, C., & Mody, K. (2013). Time matters: Temporally changing effects of planting schemes and insecticide treatment on native timber tree performance on former pasture. *Forest Ecology and Management, 297*, 49–56. https://doi.org/10.1016/j.foreco.2013.02.003.

Robinson, E. J. Z., & Lokina, R. B. (2011). A spatial-temporal analysis of the impact of access restrictions on forest landscapes and household welfare in Tanzania. *Forest Policy and Economics, 13*(1), 79–85. https://doi.org/10.1016/j.forpol.2010.08.003.

Rocha, R., Virtanen, T., & Cabeza, M. (2015). Bird assemblages in a Malagasy forest-agricultural frontier: Effects of habitat structure and forest cover. *Tropical Conservation Science, 8*(3), 681–710. https://doi.org/10.1177/194008291500800307.

Rosa, M. F., Bonham, C. A., Dempewolf, J., & Arakwiye, B. (2017). An integrated approach to monitoring ecosystem services and agriculture: Implications for sustainable agricultural intensification in Rwanda. *Environmental Monitoring and Assessment, 189*(1), 15. https://doi.org/10.1007/s10661-016-5607-6.

Rosa, I. M. D., Souza, C. M., Jr., & Ewers, R. M. (2012). Changes in size of deforested patches in the Brazilian Amazon. *Conservation Biology, 26*(5), 932–937. https://doi.org/10.1111/j.1523-1739.2012.01901.x.

Rouleau, M. D., Lind-Riehl, J. F., Smith, M. N., & Mayer, A. L. (2016). Failure to communicate: Inefficiencies in voluntary incentive programs for private forest owners in Michigan. *Forests, 7*(9), 199. https://doi.org/10.3390/f7090199.

Rudel, T. K. (2015). Have tropical deforestation's changing dynamics created conservation opportunities? A historical analysis. *Environmental Conservation, 42*(2), 108–118. https://doi.org/10.1017/S0376892914000228.

Rudel, T. K., Coomes, O. T., Moran, E., Achard, F., Angelsen, A., Xu, J., & Lambin, E. (2005). Forest transitions: Towards a global understanding of land use change. *Global Environmental Change, 15*, 23–31. https://doi.org/10.1016/j.gloenvcha.2004.11.001.

Safransky, S. (2014). Greening the urban frontier: Race, property, and resettlement in Detroit. *Geoforum, 56*, 237–248. https://doi.org/10.1016/j.geoforum.2014.06.003.

Sandewall, M., Ohlsson, B., Sandewall, R. K., & Viet, K. S. (2010). The expansion of farm-based forestry in Vietnam. *Ambio, 39*(8), 567–579. https://doi.org/10.1007/s13280-010-0089-1.

Sandewall, H. K., Wu, S., Khoa, P. V., He, Y., & Ohlsson, B. (2015). Policies to promote household based plantation forestry and their impacts on livelihoods and the environment: cases from Ethiopia, China, Vietnam and Sweden. *International Forestry Review, 17*(1), 98–111. https://doi.org/10.1505/146554815814725059.

Schmitt-Harsh, M., Evans, T. P., Castellanos, E., & Randolph, J. C. (2012). Carbon stocks in coffee agroforests and mixed dry tropical forests in the western highlands of Guatemala. *Agroforestry Systems, 86*, 141–157. https://doi.org/10.1007/s10457-012-9549-x.

Schwan, T. D., & Elliott, K. A. (2010). Effects of diameter-limit by-laws on forestry practices, economics, and regional wood supply for private woodlands in southwestern Ontario. *Forestry Chronicle, 86*(5), 623–635. https://doi.org/10.5558/tfc86623-5.

Shackleton, R., Shackleton, C., Shackleton, S., & Gambiza, J. (2013). Deararianisation and forest revegetation in a biodiversity hotspot on the Wild Coast, South Africa. *PLoS One, 8*(10), e76939. https://doi.org/10.1371/journal.pone.0076939.

Sharma, D., Vergara-Asenjo, G., Cunampio, M., Cunampio, R. B., Cunampio, M. B., & Potvin, C. (2015). Genesis of an indigenous social-ecological landscape in eastern Panama. *Ecology and Society, 20*(4), 37. https://doi.org/10.5751/ES-07897-200437.

Shi, H., Zhao, M., Aregay, F. A., Zhao, K., & Jiang, Z. (2016). Residential environment induced preference heterogeneity for river ecosystem service improvements: A comparison between urban and rural households in the Wei River Basin, China. *Discrete Dynamics in Nature and Society, 2016*, 6253915. https://doi.org/10.1155/2016/6253915.

Sinu, P. A., Kent, S. M., & Chandrashekara, K. (2012). Forest resource use and perception of farmers on conservation of a usufruct forest (Soppinabetta) of Western Ghats, India. *Land Use Policy, 29*(3), 702–709. https://doi.org/10.1016/j.landusepol.2011.11.006.

Sisak, L., Reidl, M., & Dudik, R. (2016). Non-market non-timber forest products in the Czech Republic – Their socio-economic effects and trends in forest land use. *Land Use Policy, 50*, 390–398. https://doi.org/10.1016/j.landusepol.2015.10.006.

Soriano, M., Mohren, F., Ascarrunz, N., Dressler, W., & Peña-Claros, M. (2017). Socio-ecological costs of Amazon nut and timber production at community household forests in the Bolivian Amazon. *PLoS One, 12*(2), e0170594. https://doi.org/10.1371/journal.pone.0170594.

Sorice, M. G., Oh, C.-O., Gartner, T., Snieckus, M., Johnson, R., & Donlan, C. J. (2013). Increasing participation in incentive programs for biodiversity conservation. *Ecological Applications, 23*(5), 1146–1155. https://doi.org/10.1890/12-1878.1.

Sreeja, K. G., Madhusoodhanan, C. G., & Eldho, T. I. (2015). Transforming river basins: Post-livelihood transition agricultural landscapes and implications for natural resource governance. *Journal of Environmental Management, 159*, 254–263. https://doi.org/10.1016/j.jenvman.2015.05.021.

Straka, T. J. (2011). Taxonomic review of classical and current literature on the perennial American family forest problem. *Forests, 2*, 660–706.

Su, S., Zhou, X. C., Wan, C., Li, Y. K., & Kong, W. H. (2016). Land use changes to cash crop plantations: Crop types, multilevel determinants and policy implications. *Land Use Policy, 50*, 379–389. https://doi.org/10.1016/j.landusepol.2015.10.003.

Sunderland, T. C. H. (2011). Food security: Why is biodiversity important? *International Forestry Review, 13*(3), 265–274. https://doi.org/10.1505/146554811798293908.

Tadesse, G., Zavaleta, E., Shennan, C., & FitzSimmons, M. (2014). Local ecosystem service use and assessment vary with socio-ecological conditions: A case of native coffee-forests in southwestern Ethiopia. *Human Ecology, 42*(6), 873–883. https://doi.org/10.1007/s10745-014-9704-2.

Thongmanivong, S., & Fujita, Y. (2006). Recent land use and livelihood transitions in northern Laos. *Mountain Research and Development, 26*(3), 237–244. https://doi.org/10.1659/0276-4741(2006) 26[237:RLUALT]2.0.CO;2.

Toledo-Hernández, M., Denmead, L. H., Clough, Y., Raffiudin, R., & Tscharntke, T. (2016). Cultural homegarden management practices mediate arthropod communities in Indonesia. *Journal of Insect Conservation, 20*(3), 373–382. https://doi.org/10.1007/s10841-016-9871-0.

Tolera, M., Asfaw, Z., Lemenih, M., & Karltun, E. (2008). Woody species diversity in a changing landscape in the south-central highlands of Ethiopia. *Agriculture, Ecosystems and Environment, 128*, 52–58. https://doi.org/10.1016/j.agee.2008.05.001.

Tscharntke, T., Milder, J. C., Schroth, G., Clough, Y., DeClerck, F., Waldron, A., ... Ghazoul, J. (2015). Conserving biodiversity through certification of tropical agroforestry crops at local and landscape scales. *Conservation Letters, 8*(1), 14–23. https://doi.org/10.1111/conl.12110.

Turner, B. I. (2010). Land change in the southern Yucatan: Case studies in land change science. *Regional Environmental Change, 10*(3), 169–174. https://doi.org/10.1007/s10113-010-0129-1.

Turner, M. G., Wear, D. N., & Flamm, R. O. (1996). Land ownership and land-cover change in the southern Appalachian highlands and the Olympic peninsula. *Ecological Applications, 6*(4), 1150–1172. https://doi.org/10.2307/2269599.

Upton, V., Dhubháin, Á. N., & Bullock, C. (2015). Are forest attitudes shaped by the extent and characteristics of forests in the local landscape? *Society and Natural Resources, 28*(6), 641–656. https://doi.org/10.1080/08941920.2014.933925.

Urquhart, J., & Courtney, P. (2011). Seeing the owner behind the trees: A typology of small-scale private woodland owners in England. *Forest Policy and Economics, 13*(7), 535–544. https://doi.org/10.1016/j.forpol.2011.05.010.

Van Gossum, P., Luyssaert, S., Serbruyns, I., & Mortier, F. (2005). Forest groups as support to private forest owners in developing close-to-nature management. *Forest Policy and Economics, 7*, 589–601. https://doi.org/10.1016/j.forpol.2003.10.003.

van Noordwijk, M., Suyamto, D. A., Lusiana, B., Ekadinata, A., & Hairiah, K. (2008). Facilitating agroforestation of landscapes for sustainable benefits: Tradeoffs between carbon stocks and local development benefits in Indonesia according to the FALLOW model. *Agriculture, Ecosystems and Environment, 126*, 98–112. https://doi.org/10.1016/j.agee.2008.01.016.

van Noordwijk, M., & Villamor, G. B. (2014). Tree cover transitions in tropical landscapes: Hypotheses and cross-continental synthesis. *GLPNews,* 33–37.

VanWey, L. K., D'Antona, Á. O., & Brondízio, E. S. (2007). Household demographic change and land use/land cover change in the Brazilian Amazon. *Population and Environment, 28*(3), 163–185. https://doi.org/10.1007/s11111-007-0040-y.

Verburg, P. H., Schulp, C. J. E., Witte, N., & Veldkamp, A. (2006). Downscaling of land use change scenarios to assess the dynamics of European landscapes. *Agriculture, Ecosystems and Environment, 114*, 39–56. https://doi.org/10.1016/j.agee.2005.11.024.

Vokoun, M., Amacher, G. S., Sullivan, J., & Wear, D. (2010). Examining incentives for adjacent non-industrial private forest landowners to cooperate. *Forest Policy and Economics, 12*, 104–110. https://doi.org/10.1078/1104-6899-00034.

Völker, M., & Waibel, H. (2010). Do rural households extract more forest products in times of crisis? Evidence from the mountainous uplands of Vietnam. *Forest Policy and Economics, 12*, 407–414. https://doi.org/10.1016/j.forpol.2010.03.001.

Walker, R., Moran, E., & Anselin, L. (2000). Deforestation and cattle ranching in the Brazilian Amazon: External capital and household processes. *World Development, 28*(4), 683–699. https://doi.org/10.1016/S0305-750X(99)00149-7.

Watson, A. (2017). Pioneering a rural identity on the Canadian Shield: Tourism, household economies, and poor soils in Muskoka, Ontario, 1870–1900. *Canadian Historical Review, 98*(2), 261–293. https://doi.org/10.3138/chr.3783.

Wear, D., & Greis, J. G. (Eds.). (2013). *The Southern Forest Futures Project* (pp. 552). U.S.D.A. Forest Service, Research and Development, Southern Research Station General Technical Report SRS-178.

Wear, D. N., Turner, M. G., & Flamm, R. O. (1996). Ecosystem management with multiple owners: Landscape dynamics in a southern Appalachian watershed. *Ecological Applications, 6*(4), 1173–1188. https://doi.org/10.2307/2269600.

Willis, J., Herbohn, J., Moreno, M. O. M., Avela, M. S., & Firn, J. (2017). Next-generation tropical forests: Reforestation type affects recruitment of species and functional diversity in a human-dominated landscape. *Journal of Applied Ecology, 54*(3), 772–783. https://doi.org/10.1111/1365-2664.12770.

Wilsey, D. S., & Hildebrand, P. E. (2011). Chamaedorea palm frond commercialization and certification considered from a smallholder livelihood system perspective. *Small-scale Forestry, 10*(1), 67–81. https://doi.org/10.1007/s11842-010-9131-1.

Wood, S., Rhemtulla, J. M., & Coomes, O. T. (2016). Intensification of tropical fallow-based agriculture: Trading-off ecosystem services for economic gain in shifting cultivation landscapes? *Agriculture Ecosystems & Environment, 215*, 47–56. https://doi.org/10.1016/j.agee.2015.09.005.

Wulf, M., & Kolk, J. (2014). Plant species richness of very small forests related to patch configuration, quality, heterogeneity and history. *Journal of Vegetation Science, 25*, 1267–1277. https://doi.org/10.1111/jvs.12172.

Zobrist, K. W., Gehringer, K. R., & Lippke, B. R. (2004). Templates for sustainable riparian management on family forest ownerships. *Journal of Forestry, 102*(7), 19–25. https://doi.org/10.1093/jof/102.7.19.